SCIENTIFIC AMERICAN SUPPLEMENT

Scientific American Supplement, Vol. II., No. 27.
Scientific American, established 1845.
New Series, Vol. XXXV., No. I.

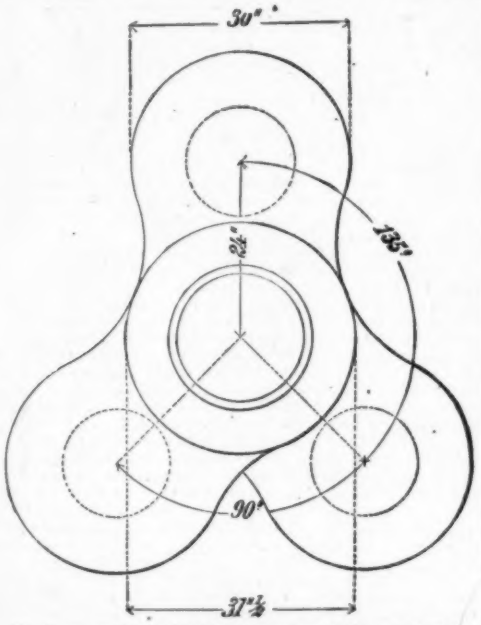
505,54

NEW-YORK, JULY 1, 1876.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.
Postage free to Subscribers.

THE CRANK SHAFT OF THE U. S. STEAMER "TRENTON."

THERE is a popular belief to the effect that American mechanics and American tools are not equal to those of Great Britain. How little ground there is for this opinion is well known to all careful observers; and it is probable that in the opportunity afforded for comparison at the Centennial American products will become better known, and their merits more generally recognized. Quite recently, we made a visit to the Morgan Iron Works, in this city, and were shown one of their latest pieces of work—the crank shaft for the U. S. steamer "Trenton"—a construction that is in every way creditable to this establishment, and is far superior, to the best of our knowledge, to any thing of the kind ever turned out of a foreign workshop. A work of this magnitude is worthy of public record, and we are sure that our mechanical readers will be interested in a description. In order to give a better idea of the size of this crank shaft, which weighs about 60,000 pounds, we annex sketches, showing the principal dimensions, Fig. 1 being an end elevation, and Fig. 2 a side elevation, with one crank partly in section. It will be seen



U. S. S. "TRENTON."—CRANK SHAFT.

that the total length of the shaft is 30 feet, and that it has three cranks, two of them making an angle of 90° with each other, and the third an angle of 135° with each of the other two—the whole shaft being built up complete without a coupling. Those of our readers who have inspected English steamers are doubtless aware that their crank shafts, even when comparatively small, are made in two pieces, with a coupling; and, judging from what has been turned out from English workshops, it seems safe to say that a shaft of this magnitude would not have been constructed in a single piece abroad.

Some remarks as to the manner in which this shaft was built up may be appropriate in this connection. It is only within the last few years, in which tools and methods have been greatly improved, that it has become common to build up large crank shafts for screw-steamers. Formerly they were forged solid and finished at great expense, and were of course open to the objections incident to the forging of such large masses, together with the fact that the rupture of any portion rendered the whole shaft worthless. The difficulties of building up a large shaft are obvious. The cranks are shrunk upon the shaft and pins, being secured by keys, in addition. If a single crank only is to be fitted, the difficulty is not so great; but when there are two or three pair, a very trifling error in each may affect the alignment very seriously. A common method in fitting up the work is to bore and finish the holes in the cranks the first thing, and then force them to their places, and this being done when they are in a heated condition, so that nice adjustments are difficult, the result is frequently far from gratifying.

The method pursued at the Morgan Iron Works is far more mechanical and satisfactory than the above. We understand its introduction is due to Mr. Henry McCullagh, the efficient superintendent of the shop, to whose courtesy we are indebted for these details. The object of the method is to avoid the errors, which become cumulative, incident to fitting up the work completely before it is put together. After the parts are forged the shafts and pins are finished, and the cranks are faced off. The holes for the crank-pins are then bored and finished, and the holes for the shafts are roughly bored, with an ample allowance for finishing. The crank-pin is next fitted into each pair of cranks, and finally secured. Now it is evident that the holes for the shafts can be laid off and finished with the greatest accuracy, so that when the rest of the work is fitted up it will all be properly in line.

Many shafts constructed in this manner have been sent out from the Morgan Iron Works, and are now doing good service; but this is the first one of such great size. As far as can be determined, it is accurate and true in every particular. Mr. McCullagh may well be congratulated on this most successful proof of his efficient supervision.

AMERICAN STEEL TIRES AT THE EXHIBITION.

THE Midvale Steel Works, of Philadelphia, exhibit their method of making steel tires for locomotive-wheels. The casting of the ingots from which the tires are made is shown by a group of six ingots with all their runners on, just as taken from the mould. The runners join the ingots at the bottom, while in the centre of the group is a runner some 6 inches square and 3 feet 6 inches high, its weight being about 600 lbs. This heavy runner operates by its weight to compress the steel in the mould, and thus to prevent the formation of air-holes in the ingots.

On the top of each ingot there is cast a cylindrical projection, or runner, so that the air-holes, if there are any, shall form therein, and this piece is broken off. In addition to the above, there is on each ingot a small tit cast, its dimensions being about ⅝ inch diameter and 1½ inches long. This tit is broken off the ingot and sent to the laboratory to be tested.

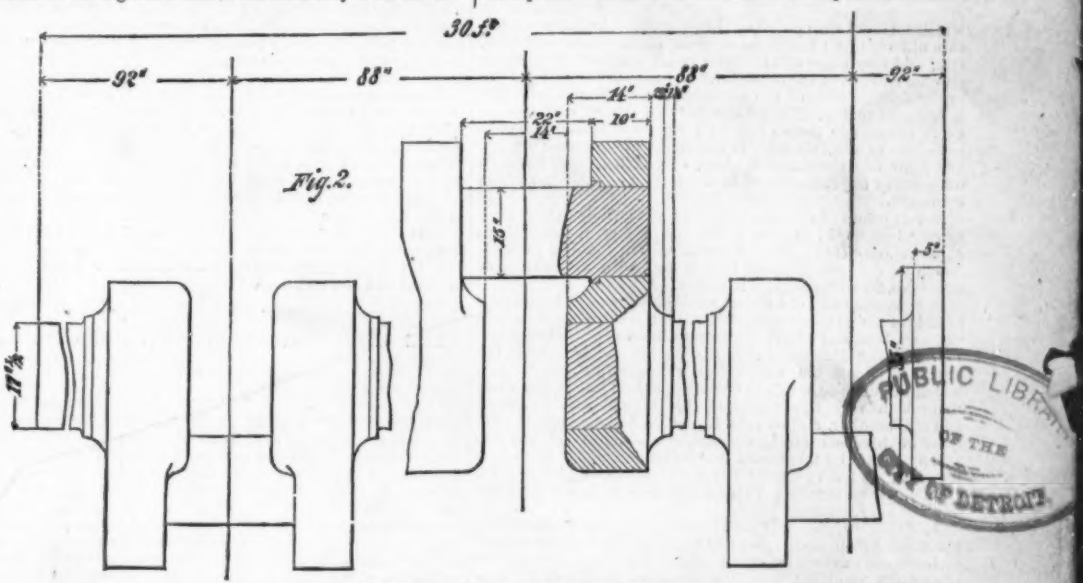


Fig. 2.

U. S. S. "TRENTON."—CRANK SHAFT.

One of the large central runners referred to was taken to Washington and tested at the United States Navy-Yard. It was first forged down, and then broken under a tensile strain, with the following result: Limit of elasticity, 62,776 lbs. in one case, and in another 67,260 lbs. per square inch; breaking strain, 122,300 lbs.; elongation under strain, 16½ per cent; reduction of diameter at the section of the fracture, 15⅘ per cent. The pieces tested are exhibited in a glass case, the grain of the metal looking exceedingly fine. The ingots for locomotive-tires vary in weight from 900 to 1200 lbs., and the first process after casting is to forge each from about 18 inches diameter and 16 inches deep to a disk of about 26 inches diameter and 6 inches thick, having a hole of about 12 inches diameter in the centre. While in this form it is termed a "punched bloom." The next process is to make it into what is termed a "becked bloom," which is done by forging on an anvil, the flange being partly formed during this process. The size of the beck is generally about two thirds of the required finished size. The becks are then formed into finished tyres by being rolled. This firm also exhibit samples of bar steel from 4 inches in diameter down to ⅞ inch octagon, and special steel made with a mild centre for use in the manufacture of taps; the steel is of the same metal all through the section, but is harder outside than in the middle of the section. This is done to prevent the taps from warping during the hardening process, and to facilitate their straightening in case they should warp. Another exhibit by the same firm is a steel lining for iron guns, similar to linings supplied by them to the United States Government. The lining exhibited is about 12 inches in diameter and 15 feet long. By its side is an ingot of Siemens-Martens steel weighing 7000 lbs., and a shaft 15 inches diameter and 50 feet long. There are also several crucible steel castings, including a heavy die, or anvil, for a steam-hammer and a railroad-crossing.

AN INTERESTING RELIC.

AT the lower end of Machinery Hall is exhibited, by Mr. David M. Meeker, of Newark, N. J., a relic, said to be of the first engine ever erected on this continent. Its history, as given by the Hon. Joseph P. Bradley, one of the justices of the United States Supreme Court, is as follows:

"It was imported from England in the year 1753 by Col. John Schuyler, for the purpose of pumping water from his copper mine opposite Bellevue, near Newark, N. J. The mine was rich in ore, but had been worked as deeply as hand and horse power could clear it of water. Col. Schuyler having heard of the success with which steam-engines (then called fire-engines) were used in Cornwall, determined to have one in his mine. He accordingly requested his London correspondents to procure an engine, and to send out with it an engineer capable of putting it up and in operation. This was done in the year named, and Josiah Hornblower, a young man then in his twenty-fifth year, was sent out to superintend it. The voyage was a long and perilous one. Mr. Hornblower expected to return as soon as the engine was in successful operation. But the proprietor induced him to remain, and in the course of a couple of years he married Miss Kingsford, whose father owned a large plantation adjoining that of Col. Schuyler. The late Chief-Justice Hornblower was the youngest of a large family of children which resulted from this marriage. Mr. Hornblower's father, whose name was Joseph, had been engaged in the business of constructing engines in Cornwall from their first introduction to the mines there, about the year 1740, and had been an engineer and engine-builder from the first use of steam-engines in the arts, about 1720. The engines constructed by him and his sons were the kind known as Newcomens engines, or Cornish engines. That brought by him to America was of this description. Watt had not then invented his separate condenser, nor the use of high pressures of steam. But it is generally conceded that for pumping purposes the Cornish engine has still no superior. After 1760 the Schuyler mine was worked for several years by Mr. Hornblower himself. The approach of the war in 1775 caused the operations to cease. Work was, however, resumed in 1792, and was carried on for several years by successive parties. It finally ceased altogether early in this century, and the engine was broken up and the materials disposed of. The boiler, a large copper cylinder, standing upright, eight or ten feet high, and as much in diameter, with a flat bottom and a dome-shaped top, was carried to Philadelphia. The relic in your possession was a portion of the cylinder, and was purchased by a person in Newark, N. J.

"In 1864 I met an old man named John Van Emburgh, then a hundred years old, who had worked on the engine when it was in operation in 1792. He described it very minutely, and I doubt not accurately. It is from his description that I happened to know the kind of engine it was; although, from the date of its construction and the use to which it was put, there could have been but little doubt upon the subject. What changes have been wrought in one hundred and twenty-two years! What mighty power has been created on this continent in that time by the multiplication and improvement of the steam-engine! We may well look upon this relic with a sort of superstitious veneration, and looking forward as well as backward, wonder what another century will bring forth."

A NEW ALPINE TUNNEL.

A COMPANY has recently been formed at Lausanne, Switzerland, to undertake the tunnelling of the Simplon. It is proposed to start at Brigue, on Swiss territory, at a height of 1920 feet above sea-level, and cut a tunnel 11.4 miles long through to Pelle, in Italy. The grade of the excavation will be on a slope of 2 feet in 1000.

THE London *Engineer* states that a few days ago a fly-wheel three tons weight, 9 feet diameter, cast in one piece, having worked for years as part of a steam-engine, was laid horizontally on two balks of timber in the yard of the West Hartlepool Cement Works, Eng.; the wheel was left perfect at night, and was found next morning fractured in several pieces, no person having touched it. The day previous the sun's rays had heated the rim considerably, and the night being cold, the arms having retained but little heat, contracted too rapidly, snapping from the boss and rim of the wheel.

PUBLIC LIBRARY OF THE CITY OF DETROIT

Scientific American Supplement.

No. 27.

FOR THE WEEK ENDING JULY 1, 1876.

PUBLISHED WEEKLY,

AT THE

OFFICE OF THE SCIENTIFIC AMERICAN,

No. 37 Park Row, New-York.

MUNN & CO., Editors and Proprietors.

O. D. MUNN. A. E. BEACH.

The SCIENTIFIC AMERICAN SUPPLEMENT is uniform in size with the *Scientific American*. Terms of subscription for SUPPLEMENT, $5.00 a year, postage paid, to subscribers. Single copies, 10 cents. Sold by all newsdealers throughout the country.

COMBINED RATES.

The *Scientific American* and SCIENTIFIC AMERICAN SUPPLEMENT will be sent together for one year, postage free, to subscribers, on receipt of $7.00.

Remit by postal order. Address,

MUNN & CO., PUBLISHERS,
37 Park Row, New-York.

THE INTERNATIONAL EXHIBITION OF 1876.

ENGLISH IRON AND STEEL EXHIBITS, PHOSPHOR BRONZE, ETC.

No. 13.

IN the British section of the Main Building may be seen another of those metallurgic exhibits—which would certainly have been more appropriately made in Machinery Hall—relating to the steel and iron industry, and which are of so deep importance to the engineering world. As, however, Great Britain makes so extensive a display in the machinery department of kindred products, it has, perhaps, been thought advisable to maintain this exhibition of the lighter and smaller specimens as a kind of branch display, which shall insure that visitors do not escape this most important part of England's industry.

The old and well-known firm of William Jessop & Sons make a most interesting display of all kinds of refined steel, which includes the special qualities adapted to the manufacture of tools of all kinds—saws, pens, reapers, fine steel wire, etc.; and they show this material in all stages of its progressive fineness, from the crude blister to that used for the razor, or the delicate tools of the watch-maker, or the mathematical instrument-maker. They have bars of refined cast steel of every practicable form of section from the square and octagonal-bar of 9 in., through to the finest watch-maker's wire; and show one circular-saw plate, of No. 3 gauge, having a diameter of 88½ inches—one of the largest circular-saw plates ever made.

In this group of exhibits, although not strictly to be classed among iron-work, is a very fine display of tin-plate from E. Morehouse & Co., for the Swansea Tin-Plate Co., among which is a single plate of tinned iron, with a thickness of about No. 20 wire-gauge, 3 x 10 feet.

C. Wm. Siemens, of London, exhibits some most interesting models of his well-known furnaces, for the various purposes in the steel, iron, and glass manufacture, among which is one of a new rotating furnace, for making steel and iron from the ore; another is his well-known regenerating gas-furnace, which has done so much to advance the iron industry. Then there is a very fine model of his crucible steel-furnace, and still another, a glass tank furnace. Among specimens of Landore Siemens steel, which are shown in considerable variety, may be mentioned a splendid specimen of boiler-flanging, and a ribbon of the metal of about 2 in. x ⅛ in. section, which has been twisted cold into a close helix without signs of rupture in any part.

The West Cumberland Iron and Coal Co. make one of the finest exhibits in their line to be found at the Exhibition, and includes specimens of every substance used in, and every grade of product resulting from, the Bessemer processes for iron and steel. All shades and grades of the ores used are shown, with explanations of their constitution, the coals in the various varieties and stages, together with spiegeleisen fluxes, etc. Among the specimens of coke—which, it will be remembered, assumes a somewhat crystalline form—is a piece having a very clearly-marked crystalline structure, which measures about 8 in. thick and 30 in. long. In one case may be seen fractured specimens of "pig," showing every grade of texture from the Cumberland Bessemer "pig," having crystals on the fractured surface fully ⅛ in. across, to the white hæmatite "pig," with a fracture like hardened refined steel. Among their samples of work is a piece of steel rail, of 57½ lbs. to the yard, 77 ft. long, weighing 1475 lbs., which was finished in 1 hour and 55 minutes from the tapping of the pig-iron from the blast-furnace; it was wound cold into a coil of about 30 in. diameter.

In another case they show samples of steel boiler-plate, which have been subjected to test, with the following results: one piece sustained a weight of 29 tons, and another 30 tons to the square inch before rupture, and both had suffered an elongation of 35 per cent when separation occurred; the sides of the show-case containing these specimens are made of polished plates of the same material as the tested specimens. A large plate of Bessemer boiler steel, about ⅜ in. thick, is shown, which has been subjected to various tests, as follows: hardened lead bullets were fired at it from a rifle at 50 ft. distance, making depressions of but about ¼ in. deep. It was then subjected to the dynamite test, by placing it flat upon a grassy sward and exploding under it at different points varying charges of that explosive. With charges of ½, ¼, and ¼ lb. of dynamite, depressions were made respectively of 3, 5, and 6 in. in depth, and 10 to 13 in. in diameter. Under a charge of 2 lbs. similarly placed, a hole of about 18 in. diameter was torn in it without detaching a particle of the material, the plate being thrown 150 ft. in the air.

Francis Holson & Son exhibit a very fine assortment of tool steels, fractured to exhibit the texture.

T. Whitwell, Stockton-on-Tees, exhibits models of his patent hot-blast furnace, and the hot-blast apparatus separately, used in the manufacture of Bessemer irons.

The Warrington Wire Rope Works, of Liverpool, show a great variety of this special manufacture, now so extensively employed in engineering works. Among these are flat braided bands of iron and steel wire for mining hoists, elevators, telo-dynamic cables, etc. This comparatively new form of wire rope is shown from 2½ to 9 inches wide.

Edge & Sons, of Shiffnal, Shropshire, also show a similar assortment of wire rope, braid, etc.

The Wigan Coal and Iron Company, of Wigan, Lancashire, make a very extensive showing of gas and cannel coals and cokes, with a remarkably fine assortment of Bessemer and hæmatite pig-irons. This is altogether the finest and most complete exhibit of the products of the initial processes in iron manufacture to be seen.

Decidedly the most interesting metallurgic exhibit in this section—although not made on a very extensive scale—is a case of articles made from that comparatively recent production, phosphor bronze. This alloy has been in use but three or four years, but such are its remarkable properties in adaptation to many of the most important engineering necessities, that it has taken great strides toward supplanting old and favorite metals and compounds. It possesses extraordinary tenacity, while it is more easily manipulated than the metals and alloys whose places it is rapidly taking. One of its most important characteristics is, that it resists abrasion and wear from frictional rubbing of surfaces far more persistently than is true of any other known metal or alloy. It exceeds in this particular even hardened steel, for some purposes.

The exhibit is made by the Phosphor Bronze Company, of London, and consists of a considerable variety of bearings and working parts of machinery, wrenches, scissors, hammers, etc., the most of which have been subjected to test appropriate to them, and the result shown. Among these are a pair of worms, or endless screws, which have been run in articulation with toothed "worm-wheels" for eighteen months in a place, and under circumstances such as had, previous to the adoption of this material, destroyed them when made of brass in twelve days; and these specimens showed but slight signs of wear after such an ordeal. A large shaft-bearing, forming a step, which had suffered more than ordinary pressure on its collar, and which had been repeatedly replaced, when made of brass, after three weeks' service, had suffered a diminution in the thickness of collar scarcely appreciable after eight months use, the mills running night and day. An eccentric-strap which had run eighteen months was reduced in thickness at the crown ¼ inch, where the ordinary gun-metal straps had been replaced every three months. Perhaps the most striking example given of the ability of this alloy to resist wear and tear is that of an hydraulic pump plunger. This plunger had been at work for 572 days at the rate of 60 strokes per minute, under a pressure of three tons to the square inch, and showed no signs of wear; while lying by its side is a hardened steel plunger which had been subjected to the same work during 60 days, and was worn down to such an extent as to be of no further use.

Phosphor bronze is one of the metallic compounds which does not contract in cooling until after the point of solidification has been completely reached, which property, in common with zinc and many of its alloys, renders the casting from it in perfection of fine-membered objects, such as busts, statuary, and other ornamental work. This property is well shown in two figures or busts, the one finished, and the other just as taken from the mould; the latter being as sharp in all its features and lines as the former.

Specimens of wire made from this alloy are also shown, with tabulated data of experimental tests made with it, which establish that, while it is more ductile than copper, it exceeds in tenacity some of the strongest of steels.

This entire exhibit will well repay a visit from even the most unprofessional man who may be in search of only general information, and contains an invaluable store for the mechanician and engineer. J. T. H.

THE INTERNATIONAL EXHIBITION OF 1876.

STEAM-ENGINES.

No. 14.

AMONG portable engines is the "Eclipse," manufactured by Frick & Co., of Waynesboro, Pa., which presents some excellent points. It has a very good kind of T girder for the bed-piece and feed-heater, and is of good design throughout. A very good feature is, that the piece answering to the king-bolt in an ordinary vehicle is a strong bracket bolted to the under side of the boiler, terminating in a ball, which with a corresponding socket on the front axle forms a "ball and socket" joint, enabling the two axles to take any angle out of horizontal parallelism with each other when drawn over rough or uneven ground. The boiler of this machine is of more than ordinarily good workmanship. This concern also exhibits a very fair, plain, serviceable, horizontal stationary engine.

The well known Shapley engine is shown in considerable variety and style, and the still better known Baxter machine is almost ubiquitous. There are no less than eleven of these engines on exhibition, the most of them in actual work at different points. It speaks well for the confidence manufacturers and others have in these engines, as wells s for the liberality of the owners and managers, that one can scarcely go into a building on the grounds requiring steam-power without finding one or more of the Baxter engines at work. There are two of them in the Government Building driving the machinery used in the manufacture of small ammunition, and one in the Post-Office Department of same building giving motion to the envelope machinery. There is one in Gillinder & Sons' glass-house, used in grinding, cutting, and polishing glassware; one in the Woman's Pavilion furnishing power to the various looms, etc. This machine had the honor of being started on the opening day by the Empress of Brazil, in imitation of the more important ceremony performed by her august partner in Machinery Hall, and has since continued on under female guidance in the hands of a pretty young feminine engineer. There is still another to be seen in the Nevada Quartz Mill actuating the stamping, crushing, grinding, mixing, and amalgamating machinery on exhibition there; and beside these are five specimens in the Exhibition space of the Company in Machinery Hall. A very elegant specimen is one which is nickel-plated in every part and highly polished. This firm also recognize the importance of letting the visitor examine the interior construction of their machines, and have one complete engine in pieces, and so placed that every part may be critically examined by all who may choose to do so. The estimate had of these engines for the furnishing of small powers could be no better illustrated than by the large number of them here in actual use.

The "Hoadley" engine is also on exhibition, and one of them, of 60 H. P., is at work, with their new and curious cut-off attachment, now so generally well known, driving the machinery in the workshops of Messrs. Stokes & Parrish. With all the acknowledged good features of the Hoadley semi-portable engine, however, there is one very radical defect: the boiler is made to subserve the purpose of engine bed or frame. The cylinder is bolted to the arch of the fire-box end of the boiler, and a casting, depressed to permit of the rotation of the crank, riveted to the other; and as the centre line of the engine is at a very considerable height from the top of the boiler shell, the strains transmitted through the top portion of the shell, due to the work of the engine, must be something enormous; and when added to the longitudinal stress due to the steam pressure must give very unequal and excessive strain to the shell. This is plainly apparent in the 60 H. P. machine mentioned, and makes it a most uncomfortable looking engine while in motion.

Williamson Bros. show some very good grooved and geared hoisting engines—one, a reversible engine, with the ordinary link, for purposes where the load is required to be run both up and down. They exhibit one form of geared hoister with vertical boiler, placed upon wheels, which must be a very handy and useful form of portable engine. Messrs. Poole & Hunt, of Baltimore, in a very extensive exhibit of other machinery, which I shall take occasion to describe at another time, show a very fine specimen of horizontal engine, with the Corliss frame. It is a plain slide-valve engine, but of first-class workmanship and design, and a machine which will do good and lasting service.

Messrs. Griffiths & Wedge, of Zanesville, Ohio, exhibit a semi-portable boiler and engine, which is a quite novel arrangement of parts for that kind of machine. The boiler is the ordinary horizontal, locomotive kind. On the back end of the boiler, is placed a kind of saddle, which forms at once a feed-water heater and bearings for the main shaft, which latter runs across the top of the boiler. Bolted to the side, and vertically situated, is a casting carrying a vertical cylinder, which is tied to the saddle-piece by a flat wrought-iron strap. In many respects this is a good arrangement, but has, in this particular case, the effect of necessitating a shorter stroke engine than could have been had with the horizontal form, and altogether it is one of those variations in design of much used machines which seems to have been made without good reason or much improvement. It is to be said of these engines, however, that in design and proportion of the details, and in workmanship throughout, they are second to none in this building, while the boiler is certainly one of the finest pieces of work of that kind ever produced. The crank-pin, connecting and piston rods, and valve stems are all of steel. The firm build also a portable engine for farm uses of the same design, and of equally excellent work.

The New-York Safety Steam-Power Co. have on exhibition six sizes of their vertical engines. The open column frame, with inverted cylinder upon its top, has been brought to a high state of perfection by this concern; and among the many who adopt this excellent form, none will be found with better proportions or more graceful outline. The castings are very fine, and the workmanship of the highest order. The arrangement for setting out the cross-head jibs is very good, and admits not only of the lost motion arising from wear being compensated for quickly and easily, but also of the alignment of the piston-rod with the guides being always kept correct; each of the jibs are adjustable vertically by means of a steel bolt and check-nuts upon the ends of the cross-head, which latter are made inclined planes upon which the back of the jibs rest, correspondingly inclined. It is a pity that, in a machine in all other respects so admirable, such an unmechanical device should be resorted to to transmit the motion of the eccentric to the valve. At a short distance from the shaft the eccentric-rod is jointed, and at this joint is also articulated one end of a horizontal lever, whose other end works upon a stud projecting from the frame; as the eccentric rotates, the distance from its centre to the joint mentioned is so short as to cause the rod to make very considerable angles with the valve stem, which must modify the action of the valve considerably; but the worst feature of it is that, as the end of the lever which is articulated to the joint in the eccentric-rod must describe an arc, the valve-stem must have a lateral motion equal to the versed sine of the arc described, instead of working in a right line; and although this may be said to be small, it is none the less an unmechanical device, and is really aggravated by the fact that the brass casting forming the valve-rod stuffing-box is of more than ordinary length, insuring that the end of the valve-rod inside of the steam-chest has quite as much lateral motion as the jointed end. With this single exception these are most admirable machines.

They exhibit also a horizontal engine, with the inevitable Corliss bed or frame, with a very neat arrangement of slide-valve placed immediately under the cylinder. They also show other varieties of their vertical engine, with the link motion for propellers and all purposes requiring a reversible machine. To show the adaptation of this form of engine to the purpose, they have in their space a steam-yacht complete in all its parts, with one of their link-motion engines for the motive power. The boat is 51 feet long, with 8 feet beam and the engine an 8 in. by 8 in. cylinder.

In the Canadian section are several steam-engines, which will, I think, be found considerably lacking in comparison with almost any thing of the kind in the Hall.

Geo. Fleming & Sons, of the Phœnix Foundry and Machine Shop, St. John, N. B., exhibit a vertical oscillating engine, in which there is little to commend, and certainly nothing novel. It is finished in almost every part, and in point of workmanship, although not of the best, will lead any thing of this kind in the section.

Mr. A. Fleck exhibits what he calls an oscillating engine, but what has been known for a long time to engineers in this country as the segmental engine. An engine of almost precisely the same design was placed on the U. S. gunboat Pequot during the late war, and was known as "Wright's segmental engine," and it will no doubt be familiar to many of your readers. What corresponds to the cylinder in the ordinary engine has the form such as would be given to a mould in which might be cast one-half of a circular ring having a rectangular section, if taken in direction of a radius. In the centre of this "cylinder," as I suppose we must call it, is cast a partition, on either side of which the steam is admitted, and alternately. What corresponds to the pistons may be taken as segments of the before-mentioned ring, one of each of which work to and from the partition as the steam is alternately admitted to and exhausted from between them. These segments are connected at the top, forming really a continuous segment of about three-quarters of the circumference, and also have arms connecting it to a shaft which occupies the centre of the circle. The ring-segment makes a partial rotation in both directions upon this shaft as a centre, and connected at its top is the connecting-rod, which, tangent to the ring or segment, transmits this motion to a crank in the usual way. The escape of steam past the pistons is prevented by stuffing-boxes at the entrances to the cylinder, which have the full size and shape of the square pistons, and which must cause a good deal of friction if kept tight. There is absolutely nothing in the entire arrangement to commend, and it does not even possess that one property which goes a little way to excuse such vagaries—novelty; and, moreover, the workmanship upon it is very poor indeed. It was made at the Vulcan Iron Works, Ottawa, under Robertson's patent.

Goldie & McCulloch, of Galt, Ontario, exhibit a horizontal

automatic cut-off engine. The cut-off is almost identical with what is known as "Wright's." A rotating shaft bearing helical cams operates to lift vertically moving slide-valves, whose fall is arrested by dashpots, and the end motion given to the cam-shaft by the regulator varies the point of cut-off. This cut-off has the grave defect of requiring a considerable amount of work to be done by the governor, under which condition it is impossible for it to be sensitive or reliable. The proportions of this engine throughout do not show that it came from experienced hands, which is also true of the workmanship.

Geo. Brush, of Montreal, presents a portable hoisting-engine, of which something better may be said. With a pulley upon the first, an engine-shaft, for ordinary work other than hoisting, and a chain-wheel for self-locomotion, this would be one of the best arranged and most useful machines on exhibition. Upon one side of a horizontal boiler is arranged a small horizontal engine. Its shaft runs across the front end of the fire-box; this shaft gears to a drum-shaft below it, which is connected at will by a sliding pinion. The fire-door is on one side of the fire-box, just clear of the hind wheels, the chimney end of the boiler being supported upon the leading axle by a suitable king-bolt. This is a very handy machine as it is, but, like all the rest of the portable engines on exhibition, must be drawn by horses. This machine, like nearly all of its class in the Canadian section, is quite indifferently made, and every thing considered, Canada can not expect to carry off many American laurels by its steam-engine exhibit.

J. T. H.

CENTENNIAL EXHIBITION—U. S. DEPARTMENT.

CLOSE under the left wing of the principal United States Exhibition Building is a small, plain-looking building, with the sign above the door "Laboratory"—in itself a specimen of an ordnance laboratory of the class in which cartridges are filled, and dangerous explosives dealt with in their final processes. It is a light and slender wrought-iron frame, covered with light, wooden weather-boards, so secured upon the outside of the frame, that while effectually excluding the rain, they will give the least possible resistance to the effects of the gases generated by any unpremeditated explosion; upon the principle that it is the confinement of the gun-barrel that makes these gases effective upon the bullet, and the weight of the bullet, combined with its velocity, that gives its terrible force at long distances from the gases that started it. Thus an ordinary musket-charge laid upon an open table would, in burning, fail to lift a bullet laid loosely upon it, and the powder so burned would not, in common language, explode, but *flash*; so the light building materials having no weight to give effective force at any distance, and not strength enough in any one part to direct the power of the explosive upon any particular point, practically reduce the otherwise terrible explosion to a mere flash of flame. But at present there appears in this building nothing more dangerous than an ordinary infantry rifle, and very light charge cartridges, while instruments are there of the finest finish and most delicate workmanship: plain circles of exact sizes for gauging shot, calipers for finding the thickness of shells; the star-gauge for determining the diameter of the bore of cannon; this is composed of steel points arranged radially upon the end of a long metallic staff, which contains a screw arrangement, by means of which the points can be thrown out from the centre, while at any point in the gun, the diameter so found being shown by a graduated scale with vernier near the outer end of the staff; also a cylinder gauge, a large brass cylinder with a long staff, used to determine whether, in boring, the gun has, from the springing of the metal or tool, assumed an elliptic or untrue section. The "feeler" is a number of points arranged upon springs at the end of a staff, so that when passed over every portion of the bore of a gun, they will detect the slightest flaw or imperfection of the surface.

In front of the door is a Springfield rifle in a "fixed rest," designed and made at the Frankford Arsenal, which holds the rifle perfectly steady in one position while firing, so that the aim does not alter, however many charges are fired. The muzzle of this gun points into a sheet-iron tube of about 10 inches diameter, and 85 feet long. Here the visitor can see the actual operation of measuring the time that the bullet takes to travel the length of the tube.

Several different instruments are here shown, all performing the same duty, all timing the bullet by causing it to cut a thread, or hit a wire or target, fixed in its path. Thus at the end of the tube nearest the muzzle of the rifle, are seen two small wires, so placed that the bullet hits them immediately after leaving the muzzle. At the other end of the tube is a target which the bullet must hit after passing the distance between it and the wires, a distance accurately measured and noted; and here it may be said, that the use of the tube is mainly to guard against possible disagreeable results from the rebound of the bullets, or the presence of the smoke in the room. These wires and the target connect with the instruments by means of two galvanic currents or threads, which are broken by the passage of the bullet. Of the instruments used for measuring and recording the interval of time between the breaking of one current by the bullet hitting the wires, and breaking the other by its hitting the target, there are two designed by Col. Benton, U. S. A., and made at the Springfield Armory; the principal difference between them being that one works by break of electro-magnetic action, and the other by break of thread, otherwise one description will do for both. In these, two pendulums are hung, so that, swinging freely upon one shaft, they pass each other in front of a graduated quadrant of bright metal; if dropped from equal elevations, on opposite sides of the quadrant, simultaneously, they will pass each other at the precise centre or zero-point of the scale. The time taken in thus dropping from one fixed elevation being found, and the scale graduated to correspond with it, it is obvious that if one pendulum be dropped ever so little while before the other, it will have the start, and pass the centre before the other gets to it, meeting the other one at some point on the other side, the difference in time of starting being exactly equal to the time occupied by the first pendulum in passing over the distance on the scale, between the point of meeting and another point equally distant from the zero, or centre. To register the distance measured, the pendulum nearest the scale is provided with a small marker, armed with printing-ink; in passing, the outer pendulum touches this marker, and pressing it upon the face of the scale, leaves a dot of ink, which the operater can note at his leisure; the distance of this dot from zero, as shown by the scale, being doubled and compared with the time-table of the pendulum, shows the precise portion of a second of time that has elapsed between the starting of the pendulums; thus the bullet, in passing one wire, being to drop the first pendulum, and in striking the target to drop the other one, the time taken in passing between these points is found. Similar to this, in that the time is measured by the swinging of a pendulum, is the electro-balistic of Vignotti, but in this the pendulum swinging in front of a sheet of paper, carries a steel point, from which a spark of electricity is made to mark the paper at each break of the current, by the bullet in passing the wires, or hitting the target; the distance between the marks upon the paper being, of course, an accurate record of the distance passed by the pendulum, while the bullet was passing from the wires to the target, and the velocity of the pendulum in every part of its course being known, the time taken by the bullet is easily deduced therefrom. Another, depending upon the law of falling bodies for its measurement of time, is the Le Boulangé chronograph, made in Belgium, which has two rods of unequal lengths suspended from electro-magnets, and dropped precisely as the pendulums in the other cases.

The shorter rod in falling sets free a knife that marks the longer rod in passing. These being adjusted so that if let go together, the knife shall mark the long rod at a fixed point, agreeing with a previously ascertained length of time in falling, it is evident that if the longer rod be let go first, this zero-point will pass the knife before the shorter rod can set it free, and the actual distance between the zero-point and the mark, as made by the knife in practice, gives the actual distance a body will fall at that portion of its descent, during the time the bullet was passing from wires to target.

The chronograph of Schultz, made in France, is different from those described, in that it measures the time by the vibrations of a tuning-fork; this tuning-fork is kept in motion or vibration by an arrangement of electro-magnetism, and holds the same relation to that power that the pendulum does to the motion of a common clock—regulates the time of the motions. These vibrations are caused to record themselves by means of a fine point held against a revolving cylinder armed with lamp-black; as the cylinder revolves, the point traces a sinuous line upon the blackened surface, each reflexion of the line showing one vibration of the fork. The bullet in passing the wires, and striking the target, causes, by electricity, a point to mark the blackened cylinder, by the side of the sinuous line of the vibrations; then, by counting the reflexions of the line between the two marks, the exact time of passing from wires to target may be known. The principal advantage of this system appears to be in that it is continuous in its action, and by setting a series of wires at known distances apart, in the trajectory, or path of the ball, it may be made to record the actual time consumed between each of the sets of wires as it hits them, and this time may be determined to the five thousandth part of a second. For comparison, here is also the old style of balistic pendulum, a small cannon hung to swing freely, and showing the strength of the powder by the length of the recoil; this gives some comparison of different powders, but no actual measurement of time and distance with small bullets or varying styles of rifle as those above will; for it is obvious that, in two different guns, with the same powder and similar balls, the results obtained above compare as the guns, or with one gun, two kinds of powder and similar balls, the results compare as the powders, etc. Next to these is a recoil dynamometer, simply a coil-spring arranged to register its movement, and used as an artificial shoulder to rest the breach of the gun against in firing.

On the other hand are the pressure-gauges, for registering the pressure of the gases during the explosion. The outside pressure-gauge consists of a strong steel tube screwed into the side of the gun-barrel, and provided with a piston made tight by a copper wad, or gas-check; the piston when driven out by the force of the explosion forces a knife-edge into a small copper plate; the same copper is then taken to an instrument provided with screw to squeeze, and scales to measure such pressure; here the same knife is forced into the same piece of copper until it marks it precisely as when on the gun, and the pressure shown by the scales gives the pressure of the gases upon the area of the piston. In practice several of these gauges are screwed into the same barrel, at regular distances from breech to muzzle, when each one registers on its copper plate the maximum pressure of the gases after the ball has passed it. Another pressure-gauge is the internal pressure gauge of Lt. Metcalfe, similar to the other in its method of making the knife-edge mark the copper plate, but having a close-fitted piston and no gas-check, the whole strongly encased so as to be placed in the cartridge itself, or in the gun before loading. Among the instruments for measuring long distances the telemeter is perhaps the most convenient for rapid approximation; it is simply a glass tube, about six inches long and three fourths of an inch in diameter, containing a clear fluid and a graduated scale, and a small plummet. In use this is held in the hand with the zero-end downward, the plummet resting at the bottom. Upon noting the flash of the gun, the tube is reversed, and the plummet starts at once to change ends of the scale. As the ball strikes, the instrument is brought to a level, and the plummet rests at the point on the scale that indicates the time the ball spent in passing from the gun to where it struck, when, if its velocity be known, the distance is easily found. From its portability and convenience for field service, it would appear to be a very complete and useful instrument.

A. V.

THE CENTENNIAL EXHIBITION — MACHINERY HALL.

THE exhibits of Machinery Hall may now justly be said to be in full working order. The space allotted to Russia is so far advanced that a day or so will find her exhibits fully arranged. The large quantity of motors and machines operated by steam are drawing so largely upon the resources of the stationary boilers that it is found difficult to supply steam at full pressure, and some few exhibits, as, for example, some of the steam-pumps, are worked intermittently when the supply of steam is found deficient.

BRAZILIAN SILK-WORMS.

In the Brazilian department there is a very interesting display made by Señor Luis de Rezende, who is a thorough enthusiast in his specialty of the propagation of silk-worms and the manufacture of silk. On the walls of the space occupied by this gentleman are several views of his farm and factory, besides a sectional plan view of the latter, which includes, in addition to the department necessary to the production of silk, apartments for the workmen and a library and theatre. Upon wooden tablets arranged in a rack, Señor Rezende exhibits silk-worm eggs, then silk-worms, one, two, three, and so on, up to twenty-five days old—those of each day being upon a separate tablet, and cared for by an attendant. In a series of glass bottles, and preserved in spirits, are specimens of silk-worms, showing each stage of silk-worm existence, "from the cradle to the grave"—that is, commencing with one day old, advancing to twenty-five days old, then from beginning to spin to the formation of the chrysalis, and, finally, the emerging of the butterfly—the whole having been produced at Rio de Janeiro. Señor Rezende exhibits also, in addition to a silk-winding machine, a "serimetre," by means of which the single threads of raw silk may be tested both for ultimate strength and the amount of stretch which takes place before the break of the thread—the two measurements being taken at one and the same time by a very delicate instrument, which is self-registering. Another machine, called a *compteur de torsion*, tests and registers the torsional strength and amount of torsion applied to the individual thread under test. Both of these machines are of French manufacture, and when we consider the delicacy of a single thread of raw silk, it will be readily perceived that their design must be very excellent, and the workmanship equally as exact to perform their duties as well as they do.

In a separate glass case are exhibited samples of cocoons and of silk produced at Señor Rezende's factory, and formerly exhibited at the Rio de Janeiro Exhibition, and in the same case are similar samples produced in the Rio de Janeiro Exhibition for display here. These are to be supplemented by cocoons and silk produced in Machinery Hall. In a separate case are arranged samples of Chinese silk from Canton, and similar samples of Japanese, Syrian, East Indian (from Bengal), French, Californian, and Brazilian silk; some of them are accompanied by cocoons. Still another case contains a collection of Brazilian butterflies, one of which, the *Aurota saturnia*, is a silk-producer. It measures about seven inches across the wings from tip to tip, and is about five inches long. Its cocoon is very much larger than that of the ordinary silk-worm, and produces about five times as much silk, the latter being of a somewhat brownish cast of color. A sample of its cocoon and a strand of silk therefrom are exhibited in a separate case. This butterfly is wild; hence it is not, as yet, utilized as a silk-producer.

BRAZILIAN COINS.

Still another case presents a collection of Brazilian coins, old and new, in copper, silver, and gold, accompanied by military medals and decorations.

Too much can not be said in praise of the pains taken by Señor Rezende to exhibit and explain his interesting display, which duties must be onerous in the extreme, since his space is continuously thronged by anxious inquirers. His wife and family are kept busily engaged, and seem to take delight in imparting information. The whole exhibit is both complete and well arranged, and reflects the highest credit upon Señor De Rezende.

KRUPP'S EXHIBITS.

The large Krupp gun is now mounted upon its carriage. Its diameter is 5 feet, its length 25 feet, and the bore is 14 inches. There are 80 rifle grooves having a twist of three eighths of a revolution in the length of the gun. The grooves are of the same width as the spaces between them. The trunnions have been turned down to receive a sleeve of brass. The weight of the gun, concerning which so many different statements have been made, is 58,460 kilogrammes, or about 64 tons. The charge of powder is given by those in charge as 500 lbs., and the weight of the shot as 1200 lbs. It is also stated that upon its trial test at Essen, in Germany, this gun penetrated a 12-inch plate at two miles distance. In addition, there is exhibited by Herr Krupp a 30-ton gun of the same pattern as the above. The crane for handling both of these guns was brought over with them; its construction, however, calls for no especial mention.

The samples of steel forgings exhibited from Essen are not so extensive as we might have expected from an establishment of such a size and world-wide renown. This, however, is no doubt largely due to the fact that the whole of the foreign exhibits of iron and steel are scarcely made with a view to finding a market here, and are intended to merely show to visitors from other countries that Herr Krupp is still the most prominent manufacturer of steel forgings. For this purpose, the exhibit is sufficiently large, being the largest in the whole of the buildings. It is altogether improbable, for example, that a pair of driving-wheels for a locomotive, made of solid steel, would be exhibited to find a market in the United States, because American cast-iron is found to fill our requirements, and can be produced at infinitely less cost. That there is a demand, however, for such wheels in countries other than the United States is at present undoubtedly true.

The steel wheels are designed for an outside cylinder locomotive, the diameters of the wheels being about five feet six inches. The spokes, hubs, and rims are forged solid. They have outside cranks in place of eccentrics, after the style first introduced in England by Crampton in his intermediate crank-shaft engines, having the driving-wheels behind the fire-box, the first of which engines were made in England about the year 1848. It was one of these engines, No. 148, which, during the Indian rebellion, carried dispatches from Dover to London, a distance of some ninety-eight miles, in an hour and twenty minutes, a great feat for twenty years ago.

Among the Krupp exhibits is a forged steel crank, which is probably the largest forging exhibited, being about 18 inches diameter and 30 feet long. It has three crank throws, and has on the end, forged solid, a face for the coupling.

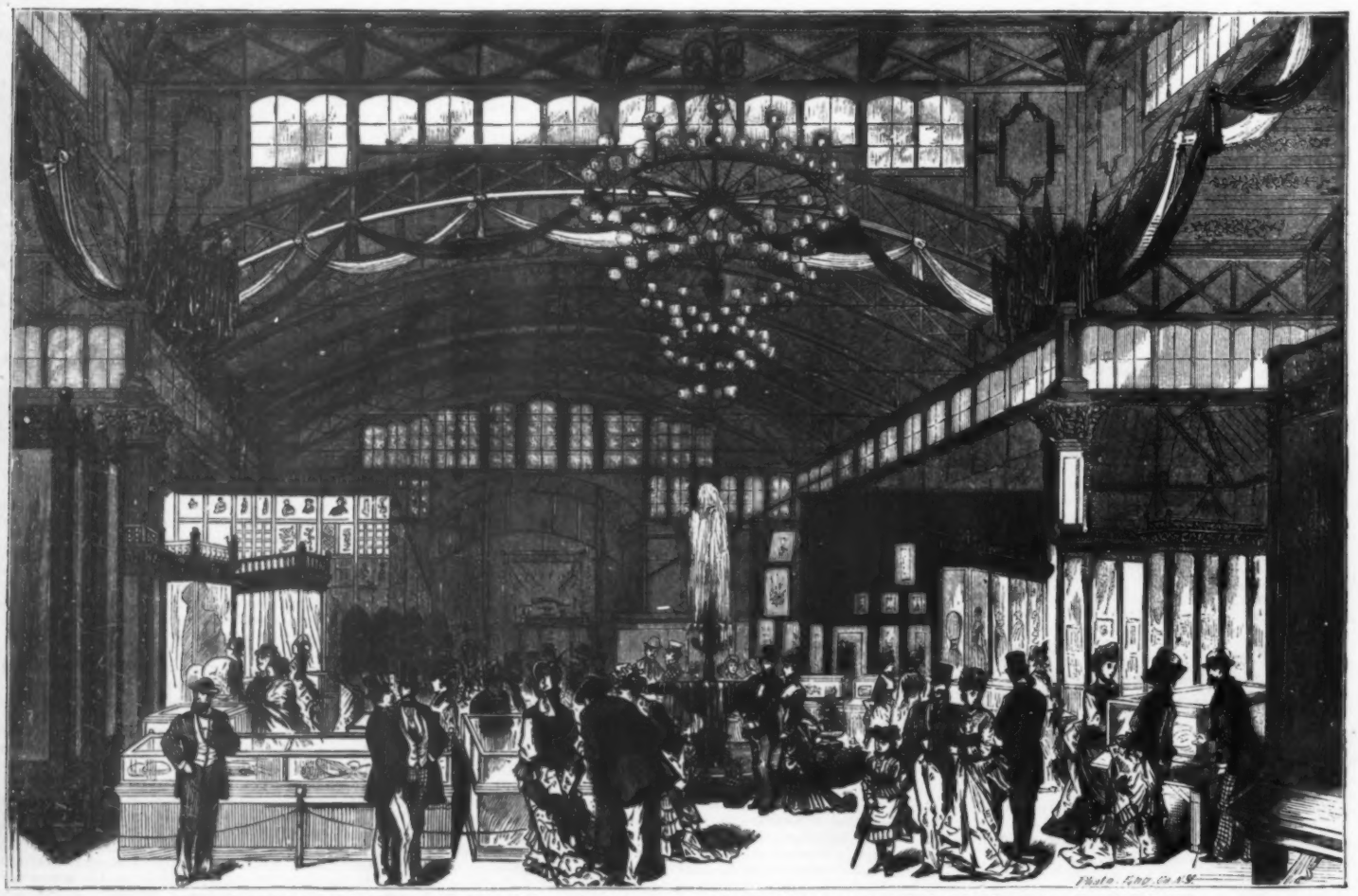
It is a well-made forging, having a skin clean and free from scale. Another exhibit from the Essen Steel Works is a steel plate 6 x 24 feet and ½ inch thick, beside which are several steel springs and some coupling or side rods forged solid. The oil-cups of these rods are forged solid on the rod ends, the desirability of which is exceedingly doubtful, since it is an expensive way to forge them, and still more expensive to manipulate them in the workshop. We are well aware that this practice is almost universal in Europe; but we think it a cumbersome and slow process to turn up and bore such oil-cups, even when the rod ends are forged separate and subsequently welded to the rod. It becomes yet more cumbersome and expensive to turn and bore them when, the ends being forged solid with the body of the rod, the whole weight of the rod in this case has to be chucked and handled in order to turn up the oil-cups. Then, again, the difference in speed at which steel and brass can respectively be manipulated forms an important consideration, and especially so when we reflect that oil-cups can, with the assistance of special tools, be made very cheaply indeed—much more so, in fact, when their manufacture is made a special branch of business than is possible by private workshops or individuals, even though the metal be the same in both cases. In one respect, however, the Krupp rods, like most others made in Europe, possess an advantage in that the part through which the keyways pass are strengthened by an ogee projection, giving as a result that the rod ends or straps are as strong at the part where the keyways are located as at any other. This, however, entails a little extra cost in fitting them up, since it is more expensive to get up a circular surface or a sweep than it is to get up a flat surface, a remark which applies still further to the detriment of forging the oil-cups solid on the rod ends. We are, however, decidedly in favor of the projections for the keyways, as being not only theoretically correct, but as also being practically an advantage.

THE WOMEN'S PAVILION AT THE EXHIBITION.

WE gave on page 113 an excellent engraving of the exterior of the Women's Pavilion, and we now present an interior view, for which and the following particulars we are indebted to our enterprising contemporary, *Frank Leslie's Illustrated Newspaper*:

The interior of the Women's Pavilion presents a scene fully as lovely as the surroundings of the elegant structure. The ground plan is in the form of a Maltese cross, 208 × 208 feet in size. The roof is in arched sections corresponding with the arms of the cross, and a dome, surmounted by a lantern, rises in the centre to the height of 90 feet. In the ornamental work of the interior there is not that gaudiness of color which makes many of the other buildings so remarkable, and some of them so objectionable, everything here being neat, tasteful, and charming. The general appearance of both building and exhibits impresses one just as a modest and beautiful young lady. The building is emphatically what its name implies—a woman's pavilion—originated and paid for by the women of America, and devoted to the exclusive exhibition of the products of woman's art, skill, and industry. The first exhibit placed in the building was some artistic needle-work executed by ladies of England. The greater portion of the exhibiting space is occupied by the women of the United States, and the remainder by those of Great Britain and Ireland, Canada, France, Sweden, and Brazil. The display covers the whole range of woman's honorable work, and embraces also illustrations of the processes by which she has attained to her enviable height as an educator. To feminine eyes, the chief attraction in the building is the exhibit of banners bearing beautifully embroidered devices, and of a bewildering variety of fancy articles of needle-work; but to the masculine inspection, the gem of the place is the Art Department. Many of the paintings and sculptures here are strikingly original, and of the highest order of conception. It is indeed a question whether any section in either Memorial Hall or the Art Annexe makes a more meritorious display.

The roof of the building is profusely decorated with the national colors of the different countries represented, and directly under the dome is a magnificent fountain from which the water is continually playing.



THE INTERNATIONAL EXHIBITION OF 1876.—INTERIOR OF THE WOMEN'S PAVILION.

MACHINERY HALL NOTES.

WOOD-WORKING MACHINERY

AMONG the wood-working machinery exhibited in Machinery Hall, the exhibit of J. A. Fay & Co. is a very prominent one. This firm contributes a band resawing machine, possessing several novel features. The lower band-wheel runs in a fixed bearing, while the upper one is in an adjustable bearing carried in a rigid upright standard or frame. Outside of the wheels, and altogether independent of the frame, is an outside connection made in two pieces, the upper piece providing a journal for the upper band-wheel, and the lower one performing a similar service for the lower band-wheel. The end of one piece is provided with a right-hand, and the end of the other has a left-hand, thread; the two being connected by a sleeve-nut containing an inside right and an inside left-hand thread, so that, connected together, they form not only an outside bearing for the two band-wheels, but act as a distance-piece, always keeping the shafts the proper distance apart, as well as relieving them of the strain which always exists when the strain on a wheel, and hence on a shaft, is outside, and not between, the bearing or bearings. This arrangement also relieves the cap of the lower bearing from strain, and places it upon the pillow-block, where it should be. When the strain falls upon the cap of a bearing, the nuts are very liable to slack back, especially if the speed of the journal is a fast one. There is no tendency, however, in this direction when the strain is taken off the cap in the manner above explained.

The guides for the saw are arranged upon rigid, independent upright standards, so that they do not spring, and are hence always in line one with the other, and do not bend the saw out of the straight line. For the back edge of the saw, instead of the customary stationary guide, which tends to crystallize and harden the edge of the saw, and by which electricity is, in consequence of the high rate of speed, always generated, there is provided in this machine a pair of friction-rollers, one above the other, and both exactly in line, thus preventing any buckling of the saw. The plane of movement of the saw is kept in the most desirable position on the band-wheels, which end is accomplished by an adjustment of the upper band-wheel, which revolves in a bearing 2½ inches in diameter by about 8 inches long.

The tension of the saw is kept at all times constant, and the expansion and contraction are therefore provided for by means of the bearing of the top band-wheel, which is distended from the lower one by means of a lever and weight. The diameter of the band-wheels is 5 feet, the saw speed being 4000 feet per minute.

The machine will take in stuff from 30 inches in width and 6 inches in thickness, down to the thinnest material that admits of resawing. Its working capacity is stated at from 10 to 15,000 feet per day, depending upon the kind and the width of the material. The saw-kerf is about $\frac{1}{16}$ inch thick, the thickness of the blade, which is 35 feet long, being number 19 gauge. The feed motion is automatic, variable, and adjustable. It is designed as follows: Upon the main shaft is a bevel friction-wheel, the bevel being slight and running from the periphery of the wheel to the shaft. Upon a shaft running at about a right angle is a smaller bevel-wheel, the latter being kept in frictional contact with the larger one, and being therefore revolved by it. The shaft to which the smaller one is fixed operates the feed-motion, whose speed is varied by causing the small beveled wheel to be in contact with the larger one at various parts of its diameter. The method of controlling this point of contact is by a lever in front of the column, and hence is convenient to the operator, who can thus regulate the feed-motion while still watching his work.

This feed-motion works easily and noiselessly, and when once set can be maintained constant, if necessary, by means of a ratchet and pawl. The driving-pulley is 24 inches in diameter and has an 8-inch face, and is designed to run at 3000 revolutions per minute.

ARMOR PLATES.

In the British department of Machinery Hall are several sections of armor plates, many of which have the edges planed for the purpose of saving cost and trouble in the handling, and of exhibiting at the same time the quality of the metal.

There is one section 6 ft. by 3 ft. 6½ in. and 11 in. thick, cut from a plate made for the "Temeraire." This plate was tested at Portsmouth, in England, on the 6th of May, 1875. The test was made with a 7-inch muzzle-loading rifle-gun, having a charge of 18½ lbs. of powder, at a range of 30 feet. The projectile was a Palliser elongated chilled-iron shot. The four indentations are each 6½ in. deep from the plane of the surface of the plate, the metal around the indentation being bulged 2½ in. outward.

Another section of armor, 7 ft. 8 in. by 6 ft. 8 in. and 8 in. thick, was tested by the English Admiralty at Portsmouth dockyard, with the following result: Eight rounds were fired from an 8-inch smooth-bore gun, charged with 13 lbs. of powder, and a cast-iron shot weighing 68 lbs. (this gun is the old 68-pounder, which was, previous to the Rodman system of gun-casting, the largest size of cast-iron gun which could be successfully made), the range of the gun from the target being 30 feet. The shots have indented the plate 2½ in. only, but have bulged it slightly at the back. The appearance of the indentations shows that the shots were completely shattered by the impact.

Another piece of armor plate is 2 ft. 10¾ in. by 34 in. and 21¾ in. thick, weighing about 20 tons. This is made for the Italian Government, and is, after the close of the Centennial, to go to Spezia and be tested by the 100-ton Armstrong gun.

PAPER-MAKING MACHINERY.

A very large exhibit is that made by W. C. Hamilton & Co., of the Riverside Mills. It consists of Gault paper-making machinery, and comprises a 72-inch Fourdrinier machine, a Gould beater-engine, and super-calendering-machine, the latter containing four rolls of chilled-iron and four of paper. The floor space occupied is about 125 by 25 ft. The whole machinery will be shortly exhibited in full operation; the material is brought in the shape of half-stuff or reduced to half-pulp. It is intended to manufacture, in Machinery Hall, fine book-paper only.

Next to the above exhibit is that of L. & E. Waldron, of New-Brunswick, N. J., which consists of a wall-paper printing-machine, running twelve colors. This machine is kept in continuous operation, and is capable of printing about 6500 yards per day. Its construction, however, calls for no special remark.

WIRE-ROPE.

Messrs. Roebling & Sons, of New-York, have inclosed their space by a railing composed of what is supposed to be the largest wire-rope ever made. It consists of six strands, with an independent wire-rope centre, containing 247 wires. This firm also exhibit the following: A section of the Niagara Falls bridge cable, containing 3640 wires of No. 9 gauge, having a strength of 6,000,000 lbs.; a section of the Covington and Cincinnati bridge cable, containing 5180 wires of No. 9 gauge, and having a strength of 8,424,000 lbs.; a section of the East River bridge cable, containing 600,078 cast-steel wires, capable of sustaining 23,300,000 lbs. In addition to the above, the same firm show bundles of telegraph-wires in half-mile lengths, and a coil of No. 24 gauge iron-wire, in one piece, weighing 47½ lbs., which is probably the longest piece of wire, of its size, in the world.

A NEW SAW-SHARPENER.

Among the novelties presented in the machinery department is a saw-sharpener, exhibited in operation, by the inventor, Mr. W. L. Covell. The machine is adapted to the resharpening of either circular, mill, or gang saws, and is designed as follows:

A revolving emery-wheel of about 12 inches diameter performs the cutting duty, the bearings carrying the emery-wheel shaft being in a fixed position. The saw being placed in a frame provided to receive it, is kept in contact with the emery-wheel, the motion of the saw being adjusted by very simple means, so that it will travel over the diametrical and radial edges of the tooth. Having finished one, the next is fed automatically to the emery-wheel, so that after the machine is set to one tooth, it requires no further attendance, but may be left until the job is completed, or even longer, since no further duty will be performed after the wheel has passed once over the saw. The feed-motion can be arranged to suit any shape of tooth, or to cut only such parts of the tooth as

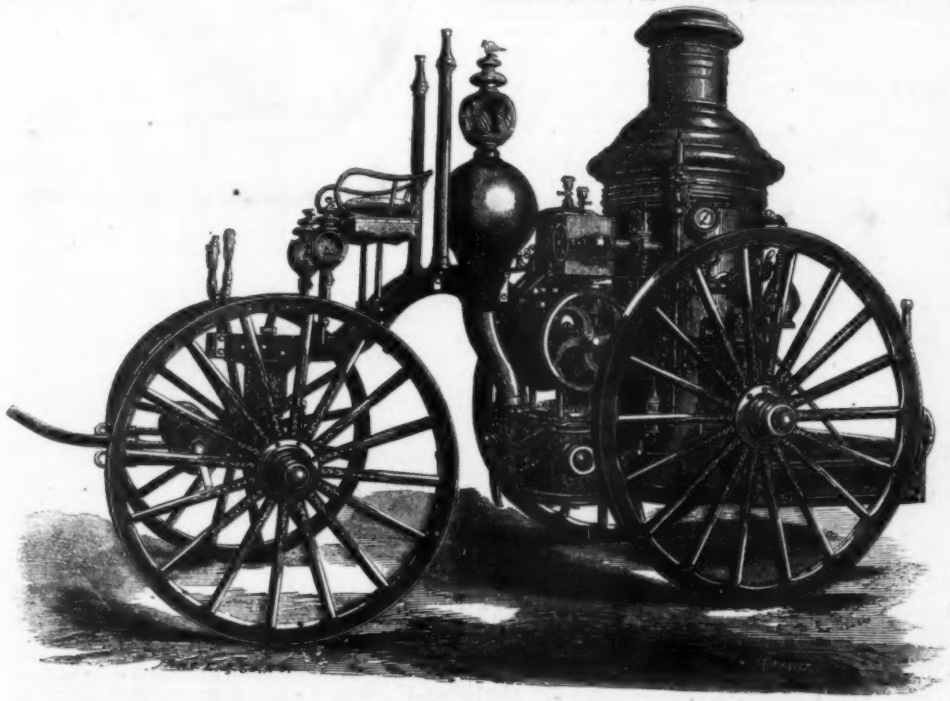
may be required. In addition to the advantage, over filing, in the saving of time, there is the more important one that the teeth must in this case be more uniform, and obviate the necessity of saw-gumming.

AN IMPROVED LOOM.

A loom, exhibited by Mr. Thomas Wood, of Philadelphia, attracts attention in that it runs 175 revolutions per minute, making cheviot 40 inches wide, the machine having one shuttle. Its side tread-motion is operated by cams, the motion of which is communicated to the levers through the medium of roller-wheels. This loom runs quicker than any other on exhibition.

COLD-ROLLED SHAFTING.

Messrs. Jones & Laughlins, of Pittsburgh, Pa., exhibit cold-rolled shafting, in lengths of 20 feet, the diameters ranging from 4½ inches down to ⅝ inch, the whole being arranged upon the sides of a triangular rack, and forming a creditable display. They also exhibit bar-iron, in 10-feet lengths, twisted from end to end, the sizes being from 8 by 1 in. downward, and plain bar, hoop, and band iron of various sizes, together with iron ore, coal, coke, and specimens of pig-iron. The pulleys exhibited by this firm are light, with straight arms and light rims, there being no super-serviceable metal in them. The patterns of both the split and soled pulleys are after the design introduced some years ago by William Sellers & Co., of Philadelphia. Some of the larger sizes have a double set of straight arms. Those exhibited range from 72 inches down to 10 inches in diameter. The remainder of this exhibit is composed of drop and post hangers for shafting, and the Collins's patent self-adjusting, double-compression couplings for shafting.



THE INTERNATIONAL EXHIBITION OF 1876.—THE GOULD FIRE-ENGINE.

THE GOULD STEAM FIRE-ENGINE AT THE EXHIBITION.

We give engravings of one of the "Gould" steam fire-engines shown at the Philadelphia Exhibition by the makers, Messrs. B. S. Nichols & Co., of Burlington, Vt. The general appearance of the engine differs in several points from those of English makers, the fore wheels being much larger than are usually employed here, while there are no seats for firemen—beyond that for the driver—and the boxes and mountings for hose, ladders, tools, etc., which add to the weight of our engines, being absent. The framing of the engine is simple, consisting of a pair of bars—or "crane necks"—which connect the boiler with the fore carriage, the latter being provided with a central spiral spring, as shown in the detail view, Fig. 2 Similar springs are also applied to the hind axle.

The boiler in the engine we illustrate is—as shown in Fig. 3—of the vertical tubular type, with a submerged smoke-box. The lower part of the shell is conical, the fire-box being also conical, so as to obtain a larger fire-grate. The taper of the fire-box is rather more rapid than that of the shell, so that the water spaces increase in width toward the top. The submerged smoke-box C has also a conical top, a form which makes a good connection with the chimney, and enables stays to be dispensed with. The tubes are of copper, and are 14 in. long by 1¾ in. in diameter. With the exception of the tubes, the boiler—which is tested to a pressure of 200 lbs. per square inch—is made of steel.

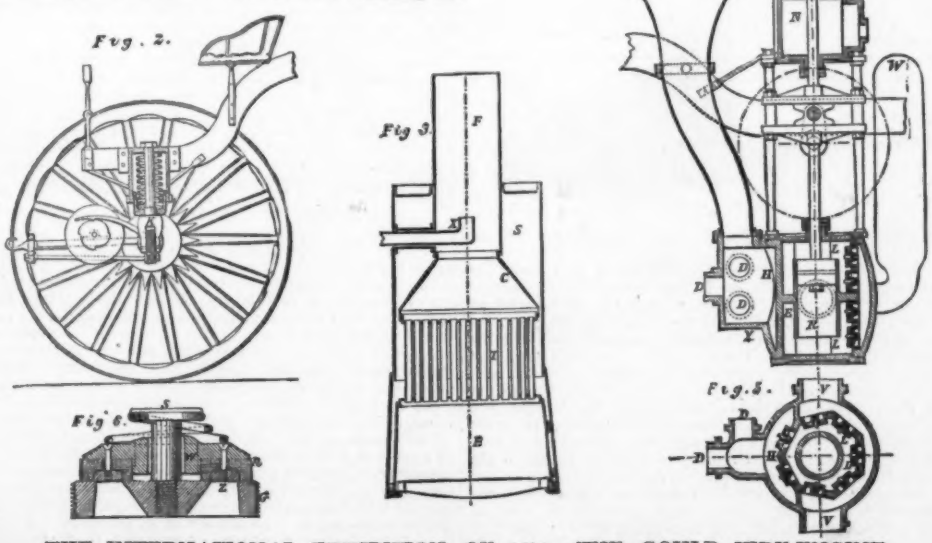
The steam cylinders and pumps are fixed vertically between the frames just in front of the boiler, Messrs. Nichols & Co.'s first and second class engines having a pair of cylinders, and their third, fourth, and fifth class engines a single cylinder. The valve-chest opens at the side in the single engines and at the front in the double engines, the slide valves being in either case readily accessible. The cylinder and pump are connected by wrought-iron columns, which are bolted firmly to the "crane necks," the cylinders being braced to both the boiler and the "crane necks," and the pump casing being braced to the boiler. The exhaust is made variable by a simple arrangement, not shown in our engravings.

The pump is shown in vertical section in Fig. 4, and in sectional plan in Fig. 5. It consists of an outer shell and the pump-barrel and valve-plate R, the barrel and valve-plate being in one casting. The partition E divides the two ends of the casing and the partitions P P separate the suction from the discharge. By this arrangement a large area of valve-plate is obtained, and in all cases the area of the suction valves for each end is slightly greater than that of the pump piston, while the delivery valve area is correspondingly large. With such ample waterways the pump works with great ease, and Messrs. Nichols & Co. inform us that it is found to take its full contents of water at all speeds. The piston is packed with a couple of cupped leathers placed back to back.

By taking off the bottom cover, the pump-barrel and valve-plates can be dropped out of the shell, thus at once exposing all the valves so that they may be readily examined or replaced. This arrangement for giving ready access to the valves is a special feature of the pump and a valuable one. In Figs. 4 and 5, D, D, D are the discharges, and V V the suctions, the water being taken in at either side, as may be required.

The position of the valves is shown in Figs. 4 and 5, while an enlarged section of one valve is given in Fig. 6. From this latter view it will be seen that the valve closes upon a seat G, which is screwed into the valve-plate. The valve W and the ring Z are of gun-metal and clip between them the india-rubber ring R. The metal ring Z, it will be noticed, is sufficiently wide to cover the opening in the valve-seat, the india-rubber ring acting as a packing. The valves are placed in a vertical plane, and each is kept up to its seat by a light spiral spring as shown, but should this spring break, the valve would still act, although not so perfectly. The water in passing each valve flows both outwards and inwards around the stem S, so that nothing is likely to stop under the valve, while as the latter is guided on the stem S by the projections W, which are sharp on the edge, it is impossible for a valve to stick up. The lift of the valves is never over ¼ in. The vacuum chamber W (Fig. 4) is large, and entirely does away with jumping of the hose, and the air vessel A on the delivery side is also capacious.

Messrs. B. S. Nichols & Co. have a high reputation as steam fire-engine builders, and they take great care to secure strength and efficiency with as little weight as possible, while, as will be seen from our engravings, the general design of their engines is very neat. A "first class" steam fire-engine of the type we have described has thrown a stream from a 1¼ in. jet a distance of 354½ feet.—*Engineering.*



THE INTERNATIONAL EXHIBITION OF 1876.—THE GOULD FIRE-ENGINE.

CONVENTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

The eighth annual Convention of the American Society of Civil Engineers commenced its session at Judges' Hall, Exhibition Grounds, Philadelphia, June 13th, Mr. George S. Greene, Esq., C.E., of New-York, President, in the chair.

CENTENNIAL HISTORY OF ENGINEERING.

Mr. Theodore G. Ellis, of Hartford, Vice-President, read a paper giving a history of engineering in this country. Washington was the first civil engineer of which the speaker had found any record. He gave some attention to canals, and was afterwards on a commission for improving the navigation of the Potomac. The year 1787 was a date of great interest to the profession. In that year, John Fitch, a Philadelphian, built the first steamboat, and there is every reason to believe that when he built it he was ignorant of Watt's improvements. He built the first propeller ever constructed in 1796; in 1798 he built the first steamboat for carrying passengers, and in 1799 ran it on the Delaware, between Philadelphia and Burlington. In 1804 Oliver Evans, of Philadelphia, constructed the first machine for building docks—a heavy, flat-bottom boat, with a chain and buckles to clear out the mud. It had wheels for land and a stern-wheel to propel it in the water. It seems to have been the archetype of stern-wheel boats. At this time stage-coaches had not come into use. In 1807 Robert Fulton built his steamboat, and in 1811 he and Mr. Stephenson built a stern-wheel boat at Pittsburg, with which a voyage was made to New-Orleans in fourteen days. This was the first steamboat on Western waters.

The introduction of stage-coaches produced a demand for bridges across the larger streams, and here was a fine field for engineering talent. Among these early structures was the magnificent 340 feet span over the Schuylkill, built in 1812 and burned in 1838. Travel between New-York and Philadelphia a century ago can be estimated from the advertisements in the daily prints of that day, naming the time at which a stage-coach would leave for New-York twice a week. On the celebration of the semi-centennial anniversary it was recorded as a matter of great wonderment that as many as three hundred New-Yorkers were in Philadelphia. In 1823 the Champlain Canal was finished and several others were in progress. About this time the evidences of progress in civil engineering began to multiply, railroads were first talked of, and there were few to prophecy what should result from their introduction. In fact, it was authoritatively stated that the claim that locomotives would some day travel twelve miles an hour was bringing ridicule and harm to the whole project.

The first locomotive run in this country was built in England, and was called the Lion. The first built in this country was constructed on West street, New-York, in 1829. It was a four-wheeler with upright boiler, and was built for the South-Carolina road. Baldwin commenced to build engines in 1833. The first iron railroad bridge consisted of three spans 55 feet long, for the Baltimore and Susquehanna Railroad Company, in 1846, built by James Mulholland. Iron suspension bridges were previously used in 1796, over Jacob's Creek, Virginia, built by Mr. Finley. Iron bridges, however, did not come into general use until just before the civil war.

In fact, in the short space of a century, American engineering has sprung from obscurity to be equal to any in the world. We have the longest bridges, with the greatest span and deepest foundations, and the only railway suspension bridge in the world; the longest railways, the best equipped, and supplied with the most comfortable conveniences. It is idle to prophecy where another century's progress may find it. The day will come when men will smile at iron bridges, when a lighter, stronger and more abundant metal will supplant iron. In aluminum is found lightness combined with strength, the only drawback to its use being the expense of extracting it from its combinations. It is not too much to expect to see bridges of a mile span made out of this metal.

It is peculiarly appropriate that the Convention should meet in this city on this Centennial year, for it is well known to most of the members that the science of engineering in this country commenced in Philadelphia, and many of the great inventions which gave an impetus to it can be traced directly to this city.

The President resigned the chair to Mr. M. C. Clark, of the firm of Clark, Reeves & Co., who will preside during its sessions.

The first regular business before the Convention was the discussion of a paper by Mr. C. Bender, printed in the May number of the society's publication, on the subject of "The theory of continuous girders in relation to economy in Bridge building."

Mr. Clemens Herschell, of Boston, who is an advocate of continuous girders, defended his position against what he considered an unwarranted attack by Mr. Bender's paper. He was replied to by Mr. Bender, who thought theorizing without practical knowledge often did much harm. He instanced a case where the calculated depression of a girder was ninety per cent greater than the actual depression when the weight of the railroad train was applied.

The further discussion on the topic was postponed.

ARCHITECTURE OF THE MAIN BUILDING.

Mr. Pettit, architect of the Main Exhibition Building, read a paper on the character of the engineering work in the construction of that building, giving the reasons for the adoption of that plan. The knowledge that there would not be a Government appropriation fixed definitely for the first time the sum that the architects felt they could depend upon. Their

work was not to draw their plans and then calculate what the work would cost, but with a certain sum of money to construct a building that would suffice for the needs of the Exhibition. A radical change in the original design was, therefore, necessary. A temporary building, to cover at least eighteen acres, must be constructed at a cost not to exceed $100,000 per acre. It must, of necessity, have a wrought-iron framework; must be built in sections, so that it could be added to if occasion demanded; must be so constructed that the materials could afterwards be used and sold; must reduce the danger by fire by placing the floorings on the ground, and building the outer walls of incombustible materials.

The building must be a mere shell; no partition walls could be afforded. There was much discussion whether it should be straight or curved work—that is, whether it should be constructed of arches or with straight trusses and rafters. The latter idea prevailed, as the material would be more salable when no longer needed. It was also found that propositions from builders favored the straight work. This determination was reached June 30, 1874. It was a design upon which both the Centennial Commission and Board of Finance were agreed. The contract was awarded to Mr. Dobbins for $1,076,000.

The work was commenced in October, and this had such a vitalizing effect on the community, that it at once became evident that the building would have to be enlarged. This was done by increasing the proposed length, and putting on the two wings, which was easily done by the plan adopted. This increased the cost to $1,420,000, which was still much less than the limit of $100,000 per acre.

The peculiarity of construction is much like the framework of a table. The long iron supports carry the dead weight, and the trusses resist the side pressure. A good test of its stability was made in February last, when a wind, causing a pressure of 18 pounds per square foot, caused no perceptible vibration. The first iron column was raised May 8th, 1874, and the last on December 2d of the same year.

The amount of iron used was 8,340,000 pounds. The iron, flat, angle, and round, measures 141 miles in length, and if made into a cubic block, it would measure 25 feet 10½ inches on each edge. There is one square foot of glass for each four square feet of surface covered.

INSTALLATION OF EXHIBITS.

In the installation of the exhibits, Mr. Pettit, who is also Chief of the Bureau of Installation, said the following general plan had been adopted: The building was divided into four great divisions by the two main avenues crossing at right angles. The attempt was made to bring the prominent nations to the centre.

The northeast corner was given to France as the representative of the Latin races; the northwest to Great Britain, as the representative of the Anglo-Saxon; the southwest to Germany, as the representative of the Slavonic races, and the southeast to America, as the representative of the coming race. By this means they are brought in as close proximity as possible, and general comparisons may be made.

MEMORIAL HALL.

Mr. Schwartzman, architect of Memorial Hall and other buildings, was called upon for a few remarks. He said the taste for architectural effect in this country had been somewhat neglected. When attempts have been made at ornamentation in great public works, there seems to have been an effort to conceal what in itself would be the best ornament. It is not probable that any distinctively new style of architecture will be introduced until new materials of construction are brought into use. The material to a great extent determines the form. Much of the expense of ornamenting bridges would be avoided, if a little more attention were paid to beautifying the lines.

It was announced that the Austrian Society of Engineers and Architects had presented to the Society their very interesting collection on exhibition in the Main Building. It consists of drawings and photographs of works projected by the members of that Society. The gift was accepted, and the President was delegated to express the thanks of the Society. —*Phila. Ledger.*

AN instrument for working six transmissions simultaneously is actually in work between Paris and Lyons, and gives 150 messages per hour on one wire. Certain difficulties had been experienced in establishing a regular service between Paris and Marseilles by the quadruplex system. These difficulties have been overcome by the application of a system of reverse currents, invented by M. Willot, an employé at the central station at Paris.—*Annales Télégraphiques.*

THE LANGEN & OTTO GAS MOTOR AT THE EXHIBITION.

THIS is a Prussian exhibit, deserving of careful attention by all who desire to avail themselves of a good substitute for small steam engines.

An explosively acting gas-engine is in reality a gun, discharging shots whose force should be fully realized and converted into steady work. The "gunpowder pile-driver" is an instance in which explosive force is converted into work, and in which that explosive force would be fully utilized were it not that the bore of the gun is so short as to allow the gases to escape at a very high pressure. But in the gunpowder pile-driver the full recoil of the gun is at once realized and converted into work, and the force expended in driving the piston or shot to the top of the shears is all (less a trifle for friction) returned and used when that shot falls. The gunpowder pile-driver is, in fact, a single-acting explosive engine, with an "exhaust" of 500 lbs. pressure to the square inch.

If, now, it were possible (1) to exhaust at atmospheric pressure, (2) to prevent waste of force in a ruinous heating of the parts of the machine, and (3) to apply the explosive force to producing steady rotary motion, the gas-motor problem would be far towards a complete solution.

(1) To exhaust at a lower pressure, requires merely a lengthening of the gun. In the gunpowder engine the volume of the charge is increased by explosion from one to 2000, hence the length of the stroke would have to be at least 2000 times the depth of the charge. The substitution for gunpowder of a gaseous explosive, in which the products of explosion are but eleven times the volume of the charge, would necessitate a length of stroke but little more than eleven times the depth of the charge.

(2) To prevent the heating of piston and cylinder, the action of the explosive force upon the piston must be unimpeded. The full amount of force is then expended in the increase of volume of the gases, and the direct propulsion of the piston.

(3) To apply the great explosive force directly in actuating ordinary machinery, is impossible. To utilize *on the return stroke* the force of the explosion stored up in the piston, is possible, but necessitates a special mechanical adaptation for its accomplishment.

In other words, the following features should, and it is claimed in this device do, find place in an economical explosion engine: 1, a free piston; 2, great length of cylinder; 3, the entire abandonment of the crank (a device of itself, irregular in action and unsatisfactory in result, even in its use with a slow and steadily expanding motive agent, as steam).

The devices for aspiration, explosion and exhaust, may best be understood from the accompanying diagrams:

The engine is shown in elevation, in Fig. 1. Fig. 2 is a vertical section of the lower portion through the slide-valve. The piston *f*, being lifted about ⅓ the length of stroke, gas and air are thereby drawn in through the channel *x*. The power to effect this movement is obtained from the momentum of the fly-wheel.

"On the igniting of the charge, the piston flies freely up to the top. As it ascends, the plenum caused by the explosion changes to a partial vacuum, reaching 22" of mercury at the top of the stroke, and thus the motion of the piston is quickly reversed and the down-stroke is performed under a pressure of about 11 lbs. per square inch, derived from the atmosphere, this driving power being communicated through the rack and toothed wheel to the shaft. When the piston has reached within a given distance of the bottom, the vacuum, which has been gradually decreasing, is again changed to a plenum, and the weight of the piston and rack expels the burnt gases during the last few inches of the stroke, thus completing the cycle of operations."

The friction clutch used to connect and disconnect the piston-rod rack with the driving-shaft, is shown in detail in Fig. 3, which gives a partly sectional view of the upper portion of the engine, in a vertical plane at right angles with the section in Fig. 2, and with the shaft. There is a pulley keyed on the shaft and surrounded by a ring, on the interior of which are cut three inclined surfaces. On each of these inclined surfaces a set of live rollers is free to travel, and to press against a corresponding curved wedge while the piston is descending; and at the same time the opposite side of the wedge which is faced with leather, presses against the pulley. While the piston is ascending, no pressure is put on these wedges by the ring, and hence, in its up-stroke, the ring can freely revolve backwards upon its bearings on the shaft; but as soon as the down-stroke commences, a firm hold of the shaft is immediately gained by the ring, and the shaft thereby becomes connected direct with the toothed wheel which gears with the piston-rod rack. As by this means the piston is free to take any length of stroke within the limit of the cylinder, it is impossible to determine exactly at what moment it shall reach the bottom; and as the apparatus for lifting it to draw in the next charge is not required to move until the return of the piston, an intermittent motion is provided for lifting the piston, which is started at the right moment by a tappet fixed to the rack.

The exhaust port being open during the entire down-stroke, there is a valve provided in the exhaust-pipe, preventing the atmosphere from entering the cylinder and destroying the vacuum, but yielding when the weight of the piston expels the burnt gases at the end of the stroke. By this arrangement the piston strokes would follow each other without any delay, if a common governor were not controlling a second stop, keeping the pawl P from falling into gear with the ratchet-wheel, moving the slide-valve, and aspiring gas into the cylinder.

This is one of the most important features of the engine. To take an example of its effect, suppose an engine is employed in hoisting, and that the load demands the exertion of its full power to accomplish the work; in this case the governor will never stop the intermittent motion of the valve-gear, and explosions will take place as rapidly as possible—say 30 per minute—while the load is being raised. Now, suppose that the load gets to the top, and the work is suddenly thrown off, the effect of this will be to increase the speed of the engine sufficiently to cause the governor to stop the pawl; and until the governor descends again by the speed dropping, the engine will not make another stroke or explosion. In some of the best of these engines there will be a pause of a minute before this takes place; or in other words, only 1-30th of the power of the engine is required to move itself whilst doing no work.

The igniting of the gases is performed by the slide-valve and two lighting jets, burning one before the other, in the valve itself, in the excavation d^3. By the motion of the valve the space d^3 first goes down and ignites its contents (gas and air), at the flame burning continually before the valve, then comes up to *x*, where it ignites the charge.

It may be interesting to mention that this gas-engine may be considered as a new form of steam-engine, inasmuch as the chief result of gas combustion is nothing but steam expanding from 2000° Fahr. down to 150° Fahr. The high pressure giving the upward motion to the piston is not lost, but the speed of the piston makes it fly much higher (see left-hand diagram, Fig. 4) than the atmospheric line, and, by forming a partial vacuum, the decrease of temperature condenses the steam.

The right-hand diagram was taken from a horizontal gas-engine acting by direct force of explosion. Nearly half the out-stroke is occupied in drawing in the charge, the return stroke being an open exhaust.

The Langen & Otto engine has the demerit of being noisy, and of requiring a very large cylinder. It has this great merit, that the governor may stop the motion of all the parts except the fly-wheel and shaft. It starts with full power at a moment's notice; uses no fuel when not running, and but little when exerting only power enough to effect the regular rotation of the fly-wheel; requires but trifling attendance; gives no trouble with coal or ashes; requires very little water; is free from danger, and does not affect insurances.

The consumption of gas, indicated by Professor Tresca, on an engine of 0.86 H. P., was 40.1 cubic feet per hour per indicated H. P., including 2 cubic feet by the lighting-jets. At present, the consumption of gas is stated to be but 26.5 cubic feet per H. P. per hour. The cost in Philadelphia would, for this consumption, be 5.7 cents per H. P. per hour. A small steam-engine, requiring 18 lbs. of coal per H. P. per hour,

FIG. 3.

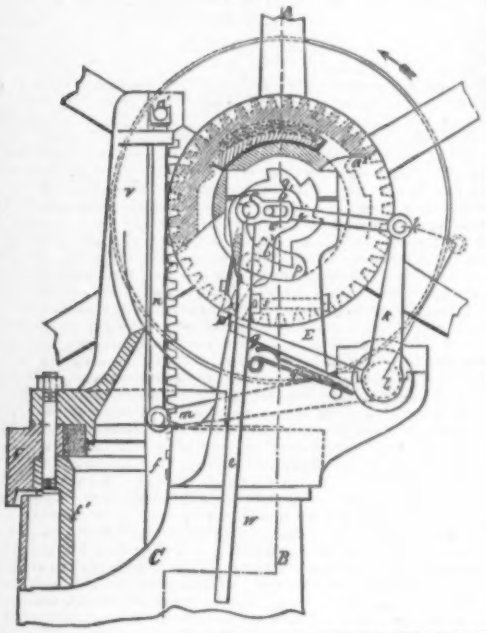


FIG. 2.

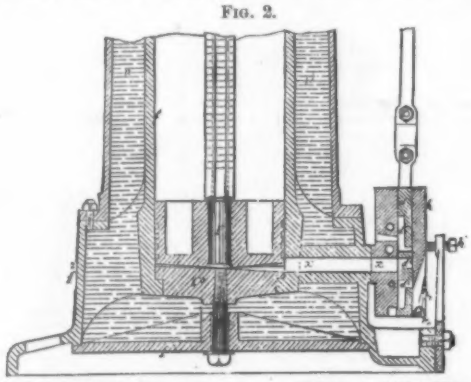
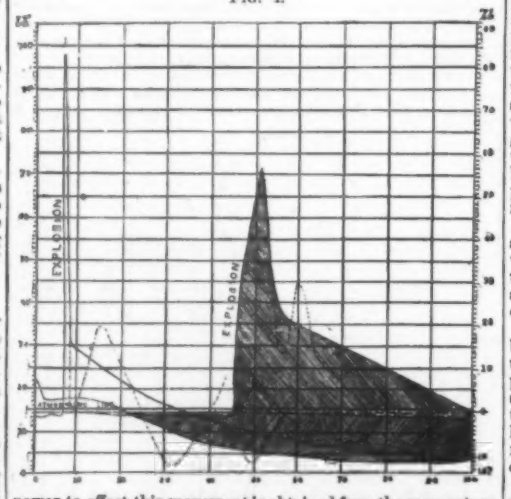


FIG. 1.

THE INTERNATIONAL EXHIBITION OF 1876.—THE LANGEN & OTTO GAS MOTOR.

FIG. 4.



would cost about 6 cents for the same power, if run continuously.

Using pure hydrogen, two-fifths the theoretical efficiency of the fuel might be realized on the brake. With 1 volume of coal-gas and 6½ of air, a consumption of 1.05 cubic feet of gas per minute should give, theoretically, 584,000 foot lbs., of which the brake shows 12 per cent. The very best steam-engine, consuming 2 lbs. of coal per H. P. per hour, uses 23,505,856 theoretical foot lbs., and gives out but 1,980,000 foot lbs., or only 8½ per cent. The patentees' agents in America are the Messrs. Schleicher Bros., 119 South Fourth street, Philadelphia.—*Polytechnic Review.*

THE RAILROADS OF THE WORLD.

DR. G. STUERMER, of Bromberg, Prussia, has for some years collected statistics of the length of railroads throughout the world. We summarize below his conclusions for the year 1875, in which we have made corrections for the United States and Canada:

EUROPE.

Country.	Opened in 1875.	Total at close of 1875.
Germany	1,493	17,372
Austria	467	10,792
Great Britain	250	16,699
France	573	13,414
Belgium	62	2,167
Holland	....	1,011
Luxemburg	....	166
Switzerland	283	1,293
Italy	196	4,777
Spain	169	3,602
Portugal	69	641
Denmark	130	783
Sweden	406	2,465
Norway	....	310
Russia in Europe	81	11,525
Turkey in Europe	....	955
Roumania	168	766
Greece	0	7
Total in Europe	4,347	88,745

ASIA.

Russia in Asia	304	623
Asia Minor	47	249
Hindostan	216	6,489
Ceylon	....	82
Java	....	162
Japan	....	38
Total in Asia	567	7,643

NORTH AMERICA.

Canada	*	4,837
United States	1,545	74,183
Mexico	50	377
Total	1,595	79,397

Dr. Stuermer notes no additions to the mileage of any country in Central or South America, Australasia, or Africa, in 1875; but there probably were some railroads constructed in South America during that year. The total mileage of each of these countries is given below:

AFRICA.

Egypt	950
Algiers	333
Tunis	37
Cape Colony	65
Mauritius	66
Total in Africa	1,451

CENTRAL AMERICA AND WEST INDIES.

Honduras	56
Costa Rica	29
Cuba	400
Jamaica	27
Colombia (Panama Railroad)	47
	559

SOUTH AMERICA.

Venezuela	8
British Guiana	60
Brazil	831
Argentine Republic	987
Uruguay	190
Paraguay	45
Chili	618
Peru	962
Total in South America	3,701

AUSTRALASIA.

Victoria	563
New South Wales	405
Queensland	263
South Australia	196
West Australia	40
Tasmania	45
New-Zealand	238
Tahiti	2
Total	1,752

SUMMARY.

	Opened in 1875.	Total at end of 1875.
Europe	4,347	88,745
Asia	567	7,643
Africa	....	1,451
North America	1,595	79,397
Central America and West Indies	....	557
South America	....	3,701
Australasia	....	1,752
Total	6,509	183,248

Thus it appears that 40½ per cent of the railroad mileage of the world is in the United States, 45½ per cent in North America, 45½ per cent in all America. Europe has 48½ per cent, Asia little more than 4 per cent, Africa about ¼ of 1 per cent, Australasia less than 1 per cent. The United States constructed more than any other country in 1875, though less in proportion to its extent than many others, and less in proportion to its population than some.—*Railroad Gazette.*

* A large amount was constructed in 1875, but we are not able to say how much.

FRENCH ACADEMY OF SCIENCES.

MAY.

On Osmium.—Osmium, in the state recently obtained by MM. St. Claire Deville and Debray, is a metal of a fine blue color, tinted with gray, and taking a violet hue when the light is repeatedly reflected from its surface. It is crystallized in very fine fragments in form of cubes or in rhomboidal figures related thereto. It is harder than glass, which it scratches easily. It possesses the highest density known—22.477. In order to prepare the metal in crystallized state, the vapor of osmic acid, many times disulted, is passed over pure carbon. To this end the vapor of benzine is decomposed by forcing it through a tube of red-hot porcelain, on which the carbon is deposited in the form of a hollow cylinder. Through this is drawn the osmic-acid vapor carried forward by nitrogen. The osmic acid is reduced, giving carbonic acid and osmium, which soon cover the interior of the carbon cylinder. A crystallized material, formed in fine coppery red scales, is encountered during this operation, which is a sesquioxide $Os^2 O^3$, and is quite inalterable in air.

On Electric Transmissions without Wires. By M. Th. Du Moncel.—[This has reference to the recent note of M. Bourbouze, regarding the possibility of transmitting signals through watercourses, using natural currents of electricity alone.—EDS.] The idea of electric transmissions without conducting wires is not new, any more than that pointing to the working of electric apparatus under the influence of currents coming from metallic plates buried in the earth, and improperly called telluric currents. Lindsay, in 1860, went so far as to suggest that with two stations, one at the south of England and the other in Scotland, and two corresponding stations in America, it would be possible to transmit directly telegraphic messages across the Atlantic. These sanguine hopes were all renounced after a serious examination. The telluric currents which may be obtained from plates buried in the soil are much more energetic than is usually believed. From the water and gas-pipes of Paris, the author in 1861, on a circuit of 2000 feet of telegraph wire (.16 inch diameter), and with a Breguet galvanometer of sinus of 30 turns, has obtained a current which at times showed a deviation of 6° 24′, and an electro-motive force equivalent to ¼ Daniell element. It was, however, very irregular. By taking two sheet-iron plates of very unequal dimensions and immersing them in a basin of water the author has likewise obtained, with a similar galvanometer of 80 turns, noticeable currents directed from the smaller to the larger plate. The action of these different currents is so energetic that their effects are recognizable in telegraphic transmissions. It may be added, that if an electric current be transmitted over a telegraphic circuit connected with the earth by a large and by a small plate, the intensity of the current is notably greater and is more constantly maintained when the small plate is positive and the large one negative, than when the reverse is the case.

On a Calcareous Alabaster from Mexico. By M. A. Damour.—[This is the celebrated Mexican onyx, of which a remarkably fine display, worked into objects of art, is to be seen in the Mexican section of the Centennial main building.—EDS.] The color varies between milk-white, yellowish-white, and and pale green. Its density is 2.77. It dissolves entirely and with effervescence in nitric acid, disengaging vapors of nitrous acid due to the peroxidation of the ferrous oxide which it contains. Analysis gives the following results: Carbonic acid, 65.2 grains; lime, 75.1; magnesia, 2.1; ferrous oxide, 6.1; manganous oxide, 3; water, 9; silica (traces), —; 149.91 grains. This may be translated into the following: Carbonate of lime, 134.1; carbonate of magnesia, 4.3; ferrous carbonate, 9.9; manganous carbonate, 5; water, 9; silica traces, —; 149.91 grains. The formula of the mineral is (Ca, Mg, Fe, Mn) C.

Analysis of Native Magnetic Platinum. By M. Terrel.—A specimen of magnetic platinum from Nischne-Tagilsk (Ural, Russia) gives, on analysis, 75 of nickel. The presence of nickel in platinum ores has not hitherto been noted, and the relatively considerable portion found in the specimen referred to is a remarkable fact.

Observations. By M. Daubrée.—The meteorites present many traits of resemblance to native platinum, while that metal, as well as the others denominated precious, have never been found, at least up to the present time, in bodies of extra-terrestrial origin which have fallen upon the earth. Under the supposition that the similitude might be completed by the presence of nickel, I requested M. Terrel to make a special research for the metal in two specimens of native terriferous and magnetic platinum. Nickel was found in both specimens, although it had hitherto been entirely unrecognized.

On the Action of Iodohydric Acid on Quercite. By M. L. Prunier.—The use of iodohydric acid as a reducing agent has enabled MM. Berthelot and Luca, who first employed iodized compounds in this species of action to change glycerine into allyliohydric ether and into propylene, and subsequently afforded a means to MM. Erlenmeyer and Wanklyn for transforming mannite and dulcite into isohexyliodohydric ether. M. de Luynes has similarly passed from erythrite to butylic alcohol. The author has sought to produce similar results with quercite, of which 154 grains pulverized were rapidly distilled with iodohydric acid (6160 grains) saturated at zero. A liquid was thus obtained which fractional distillation divided into three portions: 1. A small quantity of volatile product between 60° and 70° C.; 2. Benzine—this was the principal product; 3. Divers iodohydric ethers boiling in small quantities between 110° and 160° C.

This formation of benzine, $C^{12} H^6$, in large quantity by the reduction of a saccharine matter, such as quercite, C^{12}, H^{12}, O^{10}, which contains the same proportion of carbon, seems worthy of interest through the new relations which it tends to establish between the fatty and the aromatic series.

FLY-WHEEL DANGERS.

IN this city recently, the fly-wheel of a 20-horse-power engine, while in its usual operation, at the brewery of J. & L. F. Kuntz, corner of 168th street and Third avenue, suddenly burst. The wheel was 8 feet in diameter and weighed 3000 pounds. The fragments were hurled in every direction, one large piece flying through the roof, tearing the boards away, and making a hole 3 feet square. Another piece, weighing 200 pounds, broke through the thick brick wall immediately above the window, and made a vacant space of four feet in breadth and seven in height. Another piece, weighing about 100 pounds, was hurled across the street a distance of 200 feet, landing by the side of Turne Halle. A weight attached to the window of the engine-room was sent flying through the air, and struck the dwelling-house of J. Ducharis, immediately opposite, tearing away a foot of the front. Some of the windows of Turne Halle were smashed, as were also a few in the lager-beer saloon in front of and attached to the brewery. No other damage was done, and no person was in any wise injured.

THE CHINESE IN AMERICA.

THE Hon. Mr. Sargent, of California, in Congress, lately moved to take up the resolution recently submitted by him recommending to the President to cause negotiations to be entered into with the Chinese Government to effect a change in the existing treaty, so as to prevent the great influx of Chinese immigration to this country.

Experience, he said, has shown that Chinese population expels all other, as inferior currency expels all other kinds. The process has been going on for years in San Francisco as well as in other Pacific communities. A landlord will rent a single house in a street to a Chinaman, who at once crowds it to repletion. They take ordinary rooms, put in a false floor half-way to the ceiling, and crowd both floors, thus made, with bunks, and as many human beings as may be pressed into the space sleep therein. The atmosphere becomes fetid, and a sickly smell pervades the neighborhood, which causes the tenants of houses, right and left, to vacate. The houses can not again be rented to white persons; the rents fall, and finally the Chinese get possession. This process goes on in each direction, until the whole street is abandoned to the Chinese, as if it were a street in Hong Kong. Hotels and churches share the same fate as ordinary dwellings and stores. No class of population known to the United States can endure contact with these squalid, opium-smoking denizens. The whole street is absorbed and doomed. This process has already gone on until six large blocks in the business heart of San Francisco have been eaten out, and still the work goes on; and the future will see San Francisco a purely Asiatic city, unless some means are devised to avert this calamity. A legislative commission is now sitting in San Francisco taking testimony on this subject. The Rev. Otis Gibson, a missionary of the Methodist Church for ten years in China, and for ten years past among the Chinese of San Francisco, testifies that among 150,000 Chinese in California there are not 100 families. But the flood is not confined to the Pacific States and Territories. The Chinese follow lines of travel everywhere, and have reached the Atlantic States in numbers large enough to excite local comment and alarm.

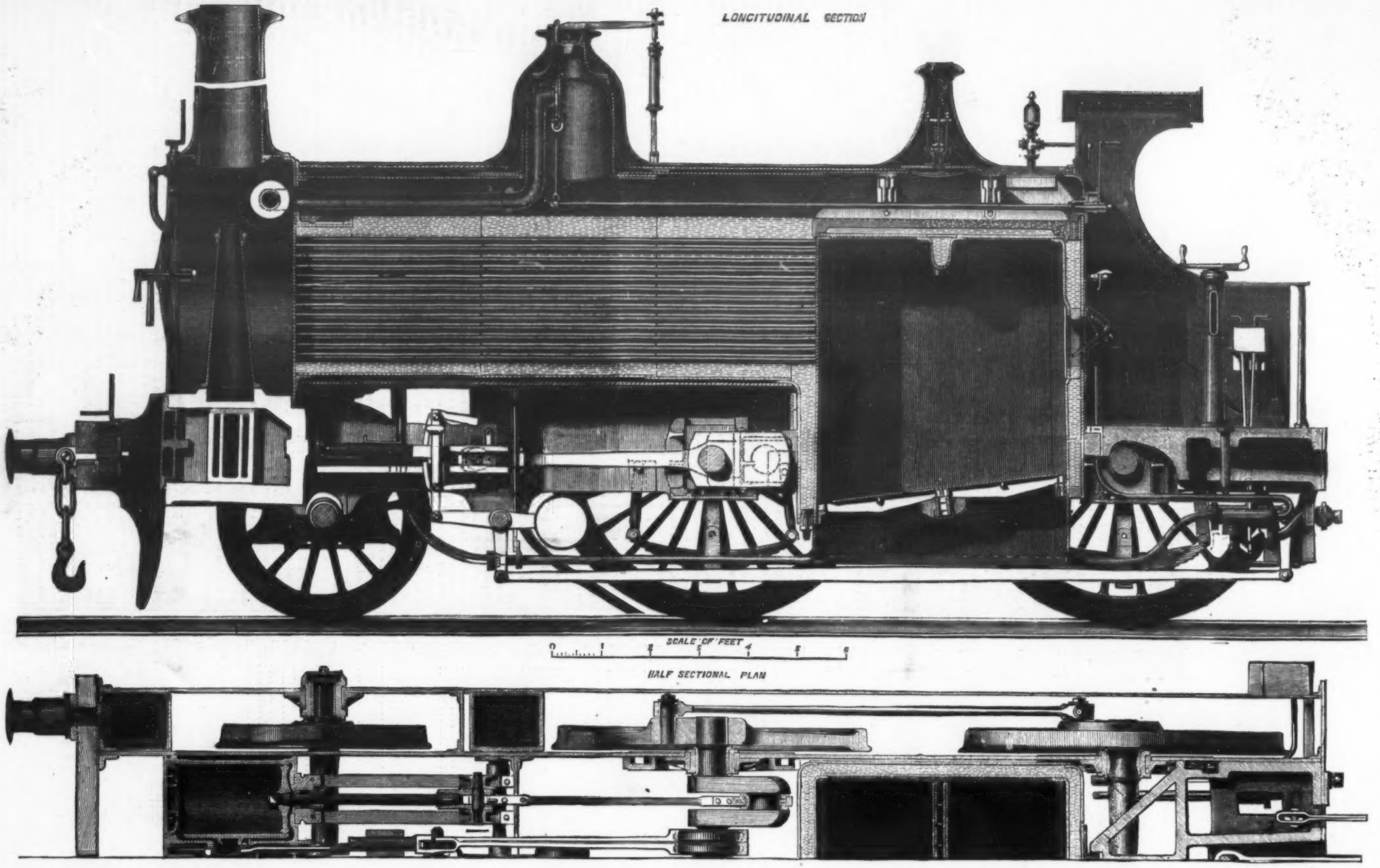
A slower growth of a community, with the elements in it only of civilization, would be preferable to rapid development by an alien heathen population. White laborers sustain families and educate their children. Europe offers to us every year hundreds of thousands of emigrants, of cognate languages, religion, civilization, and hopes. A population easily resolving itself into the mass of American society, readily acquiring our language, honoring our institutions, worshipping our God, unexcelled in industry and skill, spreads like a flood over the Western prairies, fertilizing like the swellings of the sacred river. This gives health and beauty to our political and Christian civilization. This is healthy development. Iowa has been built up by such means. Would it not be undesirable to have its population retrograde to the level of Chinese, however industrious the latter may be? The Chinaman is a constant threat to labor, skilled or unskilled. The operation of these principles has been seen on a limited scale in Massachusetts on the occasion of a "strike," where an employer at North Adams imported a sufficient number of Chinamen to carry on his establishment, and since that time has refused to employ white men. He has grown rich by the operation, but labor has been overawed, because it learned what could be done if it was not submissive. The manufacturers in California employed Chinamen because they would work for half price, letting their white laborers go; and as soon as they were taught, the Chinese set up for themselves, and undersold and bankrupted their employers, and were getting large branches of business into their own hands.

The emigration of Chinese is not like that of Europeans who seek our shores voluntarily to become citizens. Nine-tenths of the Chinamen who come to San Francisco are brought as slaves. He showed the manner in which the coolie sells himself into slavery for the price of his passage at an exorbitant rate, and mortgages his family at home. When the mortgage becomes due the family is sold off, beginning with the daughters, and the coolie sometimes returning finds a portion of the claim still unsatisfied and is himself sold for it.

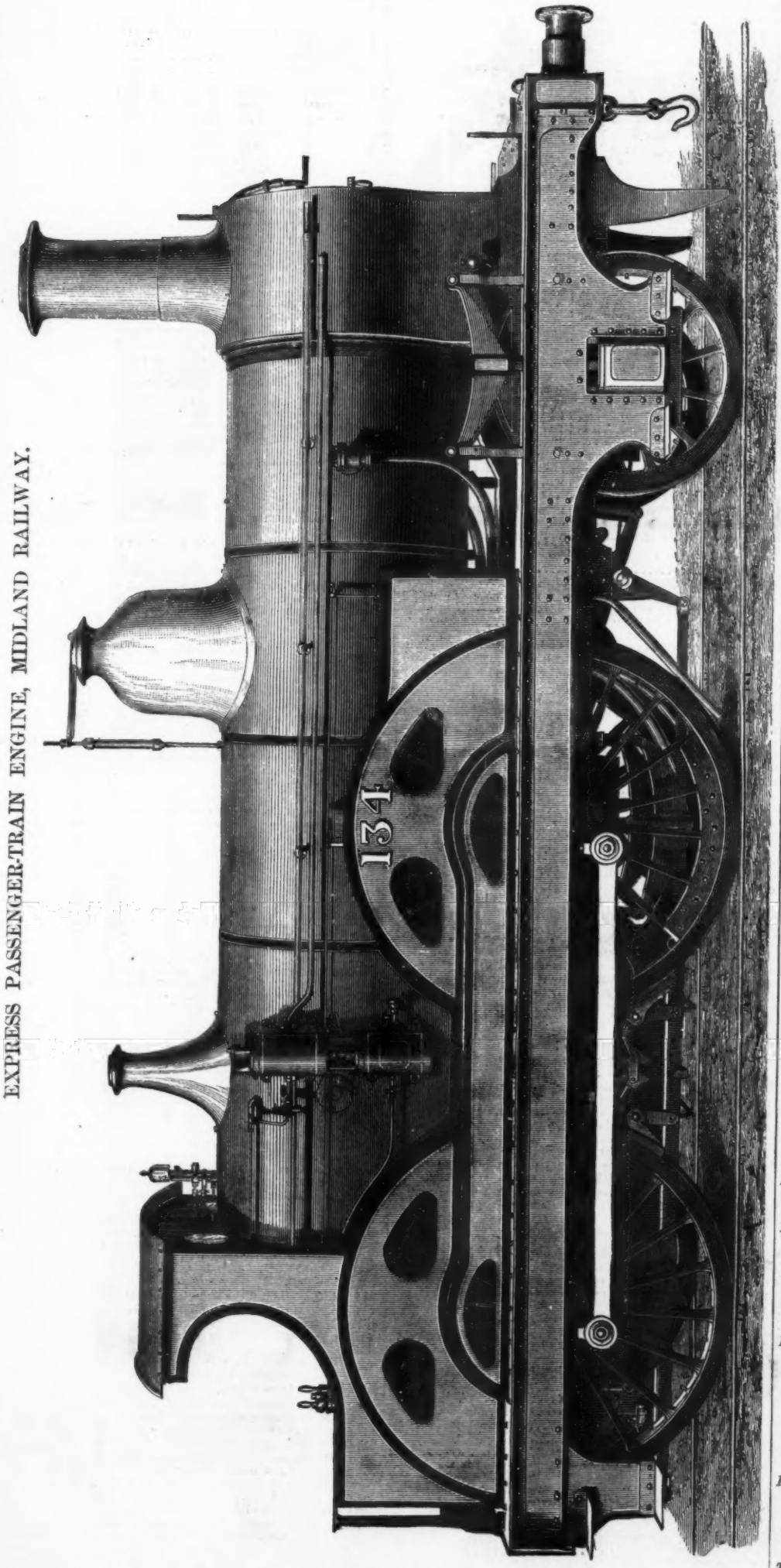
Accounts from San Francisco show that the Chinese are arriving at the present time at the rate of 1000 a week. The trade is very profitable to the ships, and the supply of coolies is ample where four hundred millions of population can be drawn upon. The danger can not be averted by belittling it. Mr. Sargent said in conclusion that it is not sufficient to say that the absorption of the country by Chinese will not occur for a century. It is our duty to determine whether this is desirable at the end of a century. If not, then we must act for those who are to come after us in a way to avert the calamity. The modification of our treaty with China, in the respects called for, will not be distasteful to China. The policy of its Government is to prevent emigration of its people.

THE TURNER'S COMPANY'S PRIZES.

THE Turner's Company, according to their custom, propose to give this year their silver medals and the freedom of the Company, and of the City of London, to any workman who may send in the best specimen of hand turning in wood, pottery, and diamonds. The competition in wood includes turning in both hard and soft wood. The work must be all hand turning, produced in the lathe without special rest or tool apparatus, and the carving must be the work of the exhibitor. The competition in pottery includes terra cotta, stone, earthenware, and porcelain, but all unglazed. The bronze medal of the Company will be given to the competitor second in merit, and the Company's certificate of merit to the third, in each of the above subjects of competition. In addition to this, the Court has placed at the disposal of the judges a sum of £30, to be distributed, according to their discretion, as money prizes, namely, £15 among the exhibitors in wood, and £15 among those in pottery. In the diamond-cutting and polishing competition, the Baroness Burdett-Coutts, who is a member of the Company, has placed at the disposal of the Court the sum of £50, to be distributed in this class among the competitors, according to the discretion of the judges. Specimens of work under this heading will be divided into classes, as follows: Class A, brilliants weighing more than one carat; class B, brilliants weighing under one carat; class C, single cut; class D, roses. In each class a prize will be given if the specimens entered are considered worthy, but the first prize of £25 and the silver medal will be adjudged to the candidate who shows the highest excellence of workmanship in the greater number of the above-named classes. In addition to the above-mentioned prize, there will be the bronze medal of the Company, and certificates of merit; the remaining £35 will be distributed according to the discretion of the judges. Candidates for the first prize must send in specimens of work in not less than three out of the four classes. For further information as to conditions of competition, application should be made to Mr. R. L. Loveland, Hon. Sec. to the Competition Committee, 4 Harecourt, Temple, London, E. C.



EXPRESS PASSENGER-TRAIN ENGINE, MIDLAND RAILWAY.



EXPRESS PASSENGER-TRAIN ENGINE, MIDLAND RAILWAY.

PASSENGER ENGINE, MIDLAND RAILWAY.

THE engines we illustrate in this impression are used by the Midland Company for working their express traffic between London, Leicester, Derby and Leeds, etc. Engine No. 134 is fitted with the Westinghouse automatic air brake. Several engines of this class are also fitted with some variety of continuous brakes—such as Clark's, Barker's hydraulic, or Kitson's steam brake, etc. The average consumption of these engines running between Leicester and London, with a load of 12.5 coaches, is equal to 34 lbs. of coal per mile; and between Derby and Leeds, with an average load of 9 coaches, equals 27 lbs. of coal per mile, using Derbyshire coal. We may remark that the road is much easier, and speeds not so high, between the latter places as from London to Leicester. The engines are fitted with two Friedmann's injectors, No. 7 and No. 9, the No. 7 being placed on the fireman's side. It is found that this size of injector by continuous working is capable of supplying the boiler for all ordinary traffic or weather. This arrangement of continuous working does away with a large amount of the waste both of steam and water attendant upon the stopping or starting of the injectors. The engines are fitted with a modification of Chatfield's fire-hole door, so arranged that the supply of air passing through the door can be regulated without throwing any glare upon the foot-plate. The engines are provided with two dry sand-boxes, worked from the foot-plate. The link gear is the ordinary Stephenson link motion. This engine is running with a 2000-gallon tender, but there are some now fitted to tenders holding 2300 and 2500 gallons.

The accompanying tabular statement gives the principal dimensions of engine No. 134:

	ft.	in.
Cylinders—		
Diameter of cylinders	1	5
Stroke	2	0
Length of ports	1	3
Width of steam ports	0	1½
Width of exhaust ports	0	3½
Width of bars	0	1
Distance apart of cylinders centre to centre	2	4
Distance centre line of cylinders to valve face	0	11½
Distance centres of valve spindles	0	3½
Lap of slide valves	0	1
Travel of slide valves in full gear	0	4½
Lead of slide valves	0	0⅛
Motion, etc.—		
Diameter of piston-rods	0	2¾
Length of crosshead slides	0	10
Length of connecting-rods between centres	5	11
Diameter of eccentrics	1	3½
Width	0	3
Throw	0	6½
Length of eccentric-rods	5	8
Wheels and Axles—		
Diameter of driving-wheel	6	8
Diameter of trailing-wheel	6	8
Diameter of leading-wheel	4	2
Distance from c. of leading to driving	8	0
Distance from driving to trailing	8	6
Distance from driving to front of fire-box	1	9
Distance from leading to front buffer-beam	4	5
Distance from trailing to back buffer-beam	4	1
Total wheel base	16	6
Crank Axle—		
Diameter at wheel seats	0	8¾
Diameter at bearings	0	7¾
Diameter at the centre	0	7
Distance between centre of bearings	3	11
Length of wheel seat	0	6⅛
Length of bearing	0	7
Section of crank arms	12 in. by 4 in.	
Trailing Axle—		
Diameter at wheel seat	0	8¾
Diameter at bearings	0	7¾
Diameter at the centre	0	6½
Length of wheel seat	0	6⅛
Length of bearings	0	7
Centres of bearings	3	11
Diameter of outside crank pins	0	3½
Length of outside crank pins	0	3½
Throw of outside crank pins	1	0
Leading Axle—		
Diameter at wheel seat	0	7
Diameter at bearing	0	5
Diameter at centre	0	6
Length at wheel seat	0	6¾
Length at bearing	0	9
Centre to centre of bearings	6	6
Thickness of tires on the tread	0	2½
Width of tires on the tread	0	5½
Frames—		
Distance apart of main frames	4	2
Thickness of frame	0	1
Boiler from Rails—		
Centre of boiler from rails	7	0½
Length of barrel between plates	10	4
Diameter at the smallest plate (outside)	4	1
Thickness of plates	0	0½
Thickness of smoke-box tube plate	0	0⅝
Lap of plates	0	2½
Pitch of rivets	0	1⅞
Fire-box Shell (Iron)—		
Length outside	5	11
Breadth (outside at bottom)	4	0½
Depth at front below centre line of boiler	5	1½
Depth at back below centre line of boiler	4	6½
Thickness of front plates	0	0⅝
Thickness of back plates	0	0½
Thickness of side plates	0	0½
Distance of copper stays apart	0	4
Diameter of copper stays	0	0⅞
Inside Fire-box (Copper)—		
Length at the bottom	5	2⅛
Breadth at the bottom	3	4½
Top of box to inside of shell	1	3
Depth of front end inside	5	11½
Depth of back end inside	5	4½
Tubes—		
Number of tubes	223	
Length	10	11
Diameter outside	0	1¾
Thickness	10 and 11 B. W. G.	
Diameter of exhaust nozzle	0	4½

Height from top of top row of tubes		0	2
Diameter of chimney (top)		1	3
Diameter of chimney (bottom)		1	4
Height of chimney from rails		13	3
Weight of Engine in working order—	tons.	cwt.	qr.
Leading wheels	11	18	0
Driving wheels	13	14	0
Trailing wheels	12	12	0
Total	38	4	0
Weight of Engine empty—			
Leading wheels	10	17	3
Driving wheels	12	12	2
Trailing wheels	12	4	0
Total	35	14	1
Heating Surface—			
Of tubes	1115 sq. ft.		
Of fire-box	110 sq. ft.		
Total	1225 sq. ft.		
Fire-grate area	17¼ sq. ft.		
Proportion of heating surface to grate area	69.7 to 1		
Proportion of fire-box heating surface to grate area	6.25 to 1		
Sectional area of tubes at fire-box end	3 sq. ft.		
Proportion of tube area to grate area	5.83 to 1		

The Engineer.

THE STEAM LOCOMOTIVE.

THE last meeting of the Master Mechanics' Association was largely devoted to the consideration of the report of its Committee on the Construction of Locomotive Engines. The committee appointed to gather facts concerning improvements, or the remedy of well-known defects in the construction of locomotives, report that in only two or three directions have valuable modifications been perfected. The committee turned its attention particularly to the consideration of questions relating to economy of fuel, locomotive trucks, spark-arresters or consumers, and the operation of consolidation locomotives. The committee report that they are in possession of no information that promises any real improvement in the form of construction of boilers, or in valves, or in machinery for working them.

In other respects, however, valuable improvements have been made, and chief among these is a spark-arrester, which, having been put to test by actual use, seems to have secured very important results. In the language of the report, it "has secured immunity from setting fires, not only arresting but perfectly consuming the sparks and smoke; also preventing the falling of fine dust from the train, improving the steaming qualities of the engine, and resulting in the saving of fuel." The only ones described in the report are those in use on the Fitchburg Railroad, and on the Camden & Atlantic. Mr. Hill, the inventor of the one in use on the latter road, describes his invention as follows:

"A deflecting plate is arranged in the smoke-box near the flue-sheet, so as to cover the top flues, and extending downward toward the bottom of the smoke-box. A steel-wire netting is placed in front of said deflecting plate to confine the circulating sparks from passing to the open air, or coming in contact with the exhaust steam. A straight pipe without any obstruction is used for a smoke-stack; the sparks after falling to the bottom of the smoke-box come in contact with an injector operated with a bell-crank and rod, under the control of the engineer. The power used to operate the injector is a small portion of exhaust steam, which can not be noticed by an expert. From the mouth of the injector a pipe is so arranged as to convey the sparks and steam to the fire-box. The moist steam used, being of a low temperature, readily combines with the smoke and gases, thereby supplying a deficiency needed to ignite them. Instead of admitting cold air into the furnace, warm, moist steam is admitted. The netting, to insure against clogging, is provided with a striker, under control of the fireman, and operated from the cab of the engine."

In regard to the operation of consolidation engines, the report presents an elaborate array of facts; although it acknowledges that they are not yet complete enough to enable the committee to judge what the effect on cost of transportation will be. The committee, after making a comparison in points of expenditure for train hands, repairs, fuel, and interest on capital invested, between the 10-wheel and the consolidated locomotives, come to the conclusion that a given amount of work may be done by the latter, at a decidedly smaller cost than by the ordinary 10-wheel engines.

A large part of the report is devoted to the discussion of the best and most economical metal for locomotive and tender bearings; and here the practice seems to be quite varied. Nearly all builders use some combination of tin and copper; but while some mix the constituents so as to form a hard brass, others use it in the form of Babbitt metal. The committee, in summing up the evidence on this subject, express the belief that a majority of builders favor hard brass, composed of 6 parts copper to 1 part tin for all axle and rod bearings. The use of Babbitt is not generally adopted for driving-axle bearings; but for truck and rod-bearings it is more often used than not, although it does not appear to give universal satisfaction. The important result seems to be recognized that Babbitt metal tends to lengthen the durability of the bearing, but to shorten that of the journal. It is generally understood that soft metal collects grit, and thus cuts away the journals, and the loss from this cause more than compensates for the saving in the wear of the bearings.

Another thing considered by this committee was the value of injectors; submitting a large number of facts, including a statistical table setting forth the observations with regard to the saving of fuel by the use of this appendage, furnished by Mr. E. T. Jeffrey, of the Illinois Central Railroad. The engine used by Mr. Jeffrey was run eight trips of 128 miles each, using her pumps exclusively, and then the same number of trips over the same section of road, using the injector exclusively. The engine burned 6342 pounds less of coal with the injector than with the pump; but nearly nine hours more time was spent in switching at way stations when the pump was used, which reduces the saving in coal to 4342 pounds. A chief objection to the use of the injector, as at present constructed, seems to be the difficulty in regulating so as to feed the proper quantity of water at all times. The committee consider that the following facts have been settled by the experiments which they have recorded:

1. A good injector properly attached is as reliable as a pump for feeding a locomotive boiler, provided the water in the tank is not heated to more than 110 degrees Fahrenheit.

2. A small saving in fuel is effected by using an injector; the boiler pressure is steadier, and the boiler is subjected to fewer changes of temperature.

3. A pump will feed only when the engine is moving, but an injector will feed the boiler when the engine is in motion, or at rest.

The report and the discussions thereon show that a locomotive is probably, all things considered, the most perfect engine yet made by man. Certainly it is the one engine which has concentrated upon its construction the most thought and ingenuity.—*Chicago Railway Review.*

WATER SUPPLY FOR TOWNS AND VILLAGES.

By CLARENCE DELAFIELD, C.E., New-York.

THE question of a water supply for the village of New-Brighton, Staten Island, near New-York City, under the Holly system or otherwise, having been submitted by the board of village trustees to Clarence Delafield, C.E., he gave in reply a report which contains much information useful in all parts of the country, from which we abstract the following:

I have considered not only the Holly system, but also the systems used under the gravitation methods, both from other pumps, as also in the case of successful boring on some point high enough to avoid the necessity of pumping.

The Holly system, as it is termed, proposes to abolish both reservoir and stand-pipe, and relies upon direct pumping through the distributing pipes, to enable it to fulfil the service, hence claims an economy in first cost of construction; also, a capacity to produce pressure sufficient at any hydrant, at short notice, to be able to throw a stream of water for fire purposes, equivalent to a movable fire-engine, thereby doing away with fire-engines and saving the cost of the same.

To determine the economy of construction, if we admit the source of water from a well to be the same, and the distribution pipes the same, it is evident that if we can save the first cost of a reservoir, say from $30,000 to $65,000, it is a very important gain; but if we use a stand pipe costing $6000, for any of the other standard pumps, the comparison is not so favorable.

For the purpose of such comparison, I have obtained the price of the pumps mentioned in the following table, and have also added the cost of stand-pipe, to wit, $6000, to enable them to be on an equality of pressure with the Holly pump, each to be capable of delivering 2,000,000 gallons of water per diem of 24 hours; the price being for pumps, engines and boilers, but in no case including buildings and the necessary foundations.

Holly direct		$27,000
Cornish,	$32,000 add stand pipe	38,000
Leavitt,	20,000 " "	26,000
Worthington,	17,500 " "	23,500
Knowles,	14,500 " "	20,500

Of course, under competition, it is fair to say that any of the above pumps might be furnished for less price, but the above table exhibits Knowles pump as $12,500 less than Holly, or with stand-pipe, $6500 less.

The next comparison is the dimension of a pump for the direct system, as against a pump for a reservoir. The direct pump requires capacity to pump for the usual domestic supply, and, at the same time, the capacity to furnish the demand for five hydrants in case of a fire call. I assume the domestic use at the rate of 2,000,000 gallons of water per diem, at present, that amount having been suggested by Mr. Holly as the capacity of the pump he offered for domestic supply, rather than the present need of the village. The domestic use per hour, at this rate, will be 83,000 gallons. If now a fire occurs, using five hydrants for one hour, under 150 feet head or pressure, there will be used 225,000 gallons, making a total demand on the pumps in one hour, of 308,000 gallons, or 7,392,000 gallons per diem; the dimension of pump required being equal to this capacity.

By the cumulative system of a reservoir, it is evident that the pumping of this extraordinary quantity for fire purposes, is distributed over, as the average distance in time of one fire from another is in no case in a village less than a week apart, allowing a full week to pump the 225,000 gallons for such fire use, or 1343 gallons per hour, which added to the domestic need, would require 2,032,232 gallons of water pumped per diem, as against the Holly capacity of 7,302,000 per diem capacity. Hence, the direct system requires pumps about three and one half larger dimensions than the reservoir system.

The stand pipe, when 200 feet high and 5 feet diameter, contains 31,000 gallons, and is no substitute for a reservoir, being valued by engineers as a relief or safety valve to the pumps and distribution pipes, permitting the pulsation of the piston rotation pumps to be expended without strain. This stand pipe may be of any altitude required, hence the pressure of water may be made by this means equivalent to any given pressure of the direct system. The stand pipe, 200 feet high, gives a pressure of 80 lbs. per inch, which, I observe, is what is deemed the proper pressure for fire purposes in the prairie towns where the Holly system has been adopted. Of course our high grounds enable us to erect a stand pipe to produce any pressure required, at much less cost than in a flat prairie country.

ECONOMY OF USE.

The next question is economy of use. The following tests were made by the professional authorities, whose names are annexed, and given as fair results of best service in each case, the duty being the number of pounds raised one foot high, with 100 lbs. of coal consumed.

Name of pump.	Authority.	Duty.
Holly	S. E. Booth, Rochester	65,515,000
	F. H. Clement, "	....
Cornish	G. H. Bailey, Belleville	70,195,143
Leavitt	Wm. E. Worthen, Lynn	103,923,215
	J. C. Hoadley	....
	James P. Kirkwood	....
	Charles Hermany	....
	Joseph P. Davis	....
Worthington	G. H. Bailey, Newark	76,386,262

From the current reports of Commissioners of Water Works, or the Superintendents, I have obtained the following prices of work done in cost of fuel only, for raising one million gallons one foot high:

Holly	Pump.	Columbus, O.	22⅞/100
do.	do.	Covington, Ky	26 1/100
do.	do.	Dayton, O.	47⅛/100
do.	do.	Dunkirk, N.Y.	61
Cornish	do.	Erie, Penn.	10⅝/100
do.	do.	Roxboro, Phila.	12 9/10
do.	do.	Schuylkill, Phila.	10 1/100
Worth'gton,	Pump.	Bellmont, Phila.	7
do.	do.	Newark, N.J.	8
do.	do.	Belleville, N.J.	8
do.	do.	Roxboro, Phila.	9 1/100
Leavitt.	do.	Lynn, Mass.	4 1/100

Assuming 1,000,000 gallons of water raised 140 feet high, and taking the best practice above, we have for cost of fuel per diem:

Holly a 22⅞/100	$33 30
Cornish a 10⅝/100	15 74
Worthington a 7	10 50
Leavitt a 4 1/100	6 23

These exhibits of duty make it evident that under the Holly system a very low economical service must obtain, which I attribute, to some extent, to the necessity of fires being kept large enough for fire service, and dampened or throttled back for domestic service only, making a constant imperfect combustion or wastage of fuel, and as this item of fuel largely determines the profits or loss in the current running of water-works, it is a most important factor in favor of one pump over another.

The cost of attendance is another item to be considered. In the direct system, the attendance of an engineer, day and night, is imperative, as fires are liable to occur at any moment. For this reason two firemen are needed, as each engineer is not able to wheel in coal, trim fires, etc., without taking him too far from fire duty. In any other system, the pumps may be large enough to run by day only, and the engineer has ample time to do his own firing, thus saving one engineer and two firemen, or say $2000 per annum. As all the pumps have been estimated capable of pumping two millions of gallons in 24 hours, it is evident that either pump could furnish the present demand of one million gallons in twelve hours, giving this saving in attendance.

There is still another question of relative cost, impossible to determine without a knowledge of locality, to wit, the foundation. On a rock bottom, of course, all are alike, but in a morass or salt meadow this question may become one of very serious import, costing many thousand dollars. The Cornish pump gives terrible service to its foundation; the Leavitt, also, is severe; the Holly, when running but one pump, is especially injurious. In this respect, the Worthington and Knowles pumps are decidedly superior, as they are self-contained, and have but little jar and less weight. Being unable to determine this cost, further discussion at this time would not be pertinent.

The strong argument used by friends of the Holly system is the value of the same for fire purposes. I have endeavored to obtain all the information I could upon this subject. The main point raised by those villages having the Holly system seems to be that, prior to having water-works, they rarely saved a frame building when once fairly ignited, whereas now they save most buildings, and hence are entitled to large deductions of insurance, etc. It would seem as though this argument might as fairly be used with any system having a similar volume and pressure of water, as no one doubts that a full supply of water, convenient to a fire, is decidedly better than no water. The question of abolishing fire engines is urged by the friends of the direct system.

At a meeting of Fire Department Chiefs, October 4, 1875, the committee on direct service supply submitted in their report as follows: "From all the facts and opinions gathered, the committee are more than ever impressed with the superiority of the reservoir system over all others, and they think that only insurmountable financial or topographical difficulties should permit the introduction of any other in preference. While a large reservoir is preferable for *storage* purposes, it is not indispensable for fire uses. A comparatively small reservoir, placed at such moderate elevation as might be gained without great expense for stone or brick work, where no natural facilities exist, would supply all that is necessary for fire-engines at fires. The amount drawn from the New-York reservoir for fires is rarely so great as to be even perceptible. The advantages of any system that exerts a uniform pressure upon the distribution pipes must be obvious to all. In the proportion that the hours in a year, during which no conflagration is taking place, exceed the hours of such conflagration, any steady pressure is preferable to any irregular one. There may be found defects in the pipes under any system; but in cases of a constant or uniform pressure breakages are less likely to occur, and if they occur, the probability is very great in favor of their taking place at a time when the exigency of a fire is not coincident with the breaking.

"There are many other considerations in favor of a regular and constant pressure; but the committee regard it unnecessary to pursue that branch of the subject in any of its phases further.

"In the judgment of your committee no system of water supply justifies a reliance upon it to the exclusion of auxiliary movable fire-engines; and, least of all, does a direct service system justify such reliance. The contingencies which attach to systems generally, are still greater in regard to that system; but whether under that or any other, in the judgment of the committee, the members of this convention owe it to themselves to declare that no system can safely dispense with the aid of auxiliary movable apparatus."

Committee { Chief BATTLE, Detroit. " CRONIN, Washington; " MCFADDEN, Memphis; " GIBSON, Rochester; And others.

It would seem from the experience of these gentlemen that we dare not save by dismissing any of our present engines; and as Messrs. Gibson and McFadden are both representatives of cities having the Holly system, we must give due weight to their opinion. Besides, the fact that parts of the village of New-Brighton would be without hydrants, proves that there would be no possibility of such a course. The point raised in this report of fire chiefs, as to the undue strain upon the service-pipes during fire, is one of great moment, and bears very hard upon house-plumbing; also in case of the breakage of a main during this unusual strain, no pressure could be maintained upon the hydrants, and the whole system would be comparatively inert until it was repaired. In Binghamton, N. Y., a boiler belonging to the Holly pump exploded, and for a day the city was without protection from fire, or water to drink. Any boiler may, from abuse or hidden defect, place a city at this disadvantage. With a reservoir, in case of disaster to a pipe, the section can be cut off at once on both sides, and the circulation remain on all sides. In case of fire, the attachment of the suction-hose of an engine to a hydrant would probably reduce the pressure in the service-pipe, so that during this critical period of its use there is really less liability to accident, on account of reduced pressure. The assumption that Holly can produce greater pressure by pump than can be obtained by altitude from a

reservoir, is wholly unfounded in fact, and really is the basis of the whole argument for use of the hydrants without fire-engines; and all the statements made in his pamphlet in relation to the saving of property from fire, are made as against no water-works; and as far as the use for firemen is concerned, the same number are needed for hose-carts and the use of the hose. The question of friction in the service-pipes is as much against the Holly system as against the gravitation system, and if the demand is for any given pressure, it is at once answered by the erection of a stand pipe of equivalent pressure from its altitude, or a reservoir of equal altitude.

We have, as a result of the foregoing examination:

First. Holly's pump, engines, and boilers cost $12,500 more than Knowles' pump, etc.

Second. Holly's pump, etc., costs $6500 more than Knowles' pump, etc., with stand-pipe.

Third. A pump of Holly's pattern must, for his direct system and for fire use, be 3½ times as large as a pump with reservoir for storage.

Fourth. Holly's system of pumping costs for coal 5½ times more than Leavitt's, by actual yearly test, or three times more than Worthington's.

Fifth. Holly's system requires twice the constant attention that any storage system would, and will not permit a minute of inattention, hence requiring a first-rate order of men to attend it.

Sixth. Holly needs heavy, expensive foundations—Worthington and Knowles' slight, by comparison.

Seventh. Holly can not possibly send a higher and larger stream from a hose than can be sent by means of the gravity system, and as every pipe and all house service is necessarily adapted to the greatest pressure, the service must be constructed alike. Hence, the constant, even pressure from the reservoir must be preferable for instant use in case of fire, and at such times easier to the service-pipes than the waves of pressure delivered from the piston-pumps.

Eighth. The opinion of the chief engineers of various cities, and our rural area, will prevent us from selling the fire-engines, and thus saving capital and cost by any system.

Ninth. The fatal effect, in case of a radical break-down of pump, engine, or boiler, or any important fracture of a main-pipe, renders the direct system vastly inferior to the reservoir or storage system; and as citizens gradually lose their wells and cisterns after the introduction of water-works, any such break-down is a calamity little less serious than the loss of the air we breathe.

Being familiar with various pumps, I express the opinion that no rotative piston-pump can be continuous in its discharge as is evidenced by the water-cards; and that Holly's pump is not equal in this to the Worthington pump, which, for heavy, continuous work, I believe to be superior to any other at present manufactured. The Leavitt pump, at Lynn, Mass., is the most desirable for economy of running, but requires much heavier foundations, and is more expensive in repairs.

From the foregoing reasons and conclusions, I recommend, therefore, that the Holly system or direct system be not adopted.

Mr. Delafield then proceeds to discuss the question of the source of the water supply, and concludes that, owing to the insular character of the soil, the absence of suitable natural reservoirs and streams, a thorough experiment with artesian wells should be undertaken. After a study of the geological formation, he thinks that sufficient water can be thus obtained. We subjoin a few extracts from his observations:

I believe that the serpentine rock rests upon the gneiss rock, the usual intermediate rock being absent, and the reason for this belief is that the gneiss of New-York City is observed dipping under the bay, arising to form Robin's Reef, and extending west to the beacon opposite New-Brighton, probably passing under Staten Island at the same rate of dip.

As the result of observation of American and European engineers, the magnesian limestones are prolific water-bearing rocks, and the primitive gneiss liable to fissures and stratification, leading from great distances and bearing water of great purity. The granite from its freedom from fissures or strata, and irregular contour may form good basins, but rarely carries water far. Geology is by no means an exact science, as far as determining without experimental examination the probable strata or their water-bearing conditions; but the above-mentioned conditions are an assistance in an intelligent consideration of the subject now under investigation.

I find, by observation, that there is a series of admirable springs, commencing at the famous Hessian Springs, near Lafayette and Brighton avenues, below Silver Lake; also the Bement boiling springs, then various lesser springs, to the large springs at the Four Corners, or Constantz Brewery, and so on to the Willow Brook, and down to Springville. I have estimated, and find the amount of water discharged is vastly in excess of any surface drainage on the higher grounds of the island adjacent, and am thus led to the belief that these springs arise from the rock below, and have their source on hills far distant.

Experience, from the history of the oldest boring for water, found in China, to the modern practice of France and England, illustrates the feasibility of finding an ample supply of water in both places for the use of dense populations; therefore, the most conservative engineer finds ample precedent for such practice where the conditions of water-bearing rock are present. These conditions do underlie certain portions of the island, and from the positive proof of the springs mentioned, I believe that by boring on ground, properly selected, adjacent to some of the larger springs mentioned, that water in ample quantities could be found.

COST OF BORING ARTESIAN WELLS.

The cost of boring, as now common in New-Jersey and Pennsylvania with the diamond drill, is about $6 per foot for the first one hundred feet, and one dollar per foot additional in an arithmetical proportion for each succeeding one hundred feet.

I estimate the magnesian limestone as 350 feet thick; it rarely ever averages over 300 feet. If water should be found at this depth, the cost for six-inch hole would be:

100 feet		$600
Second 100	"	700
Third 100	"	800
Fourth 50	"	450
Total 350 feet		$2,560

This depth would, no doubt, be ample for the lower position in case of pumping. But for a test bore on high ground, I would advise that not less than one thousand feet should be tested, unless ample supply was discovered sooner. A bore of this depth would search down into the strata and fissures of the gneiss rock, and would finally settle the question of the value of an artesian well on this island. The cost would not exceed $10,000, and I would desire to have this tested first, for the sake of economy, in case of success in finding water, and if not able to find water at such altitude, to determine the utility of seeking lower grounds indicated west or south of Port Richmond. In case the highest ground should be successful, the long mains between bore and distribution system of pipes would be ample as a reservoir to equalize the unequal demand for water in common use, as such main, 15 inches diameter, would contain in one mile 60,000 gallons. But for fire use, it would be desirable to have a reservoir of capacity, say, equivalent to fire demand of 260,000 gallons, which would cost, say $2000.

The purity of water for use in domestic affairs is one to be determined by a competent chemist, as it is possible to find water by any method unfit for use. The water from deep bores, especially from the primitive rock formations, is usually found most free from foreign surfaces. Surface drainage stored in catchwater basins is apt to acquire most vegetable matter in solution. Water from gravel strata under clay formations is most likely to have large traces of salts of the earthy bases, and be a hard water. But water liable to receive by direct drainage or filtration the excreta of animals from either cesspools, water-closets, or barn-yards can not be too carefully excluded from domestic use, and is nearly certain to lead to fatal results.

Water with decaying vegetable matter is liable to produce periodic diseases, and wells in the low lands are often sources of this poison. These poisons may all be so diluted as to be impossible to detect, except by the delicate tests of the chemist. In fact, water absolutely poisonous from any of the foregoing objectionable causes may be more desirable to the eye, or grateful to the sense of taste, than absolutely pure, distilled water. Many wells on the island are highly improper for use, and when tested with a drop of nitrate of silver solution exhibit a white, cloudy reaction. This is either the chloride of sodium, or calcium, or magnesium, and is largely the cause, in the case of chloride of calcium, of the kidney and bladder difficulties so prevalent. The present cisterns are by no means agreeable, as in the populous neighborhoods the roofs of houses are covered with the dust of streets, partly composed of the excreta of animals using the same. The air is contaminated with the gases of decaying animal and vegetable matter, that saturate the falling rain, and are carried into the cisterns, where, were no filters used, the water would soon exhibit a foul mass. The supply by this method soon proves inadequate in dense populations, and already in portions of New-Brighton large sums are expended for hauling water.

COST OF WATER-PIPES FROM 2 TO 12 INCHES DIAMETER.

The sources and modes of supply being considered, the distribution is next to be considered. I have examined the various streets, and have selected such as seemed to be probable from population to prove remunerative, and have included some alone for the purpose of circulation, so that in case of needed repairs the system could be in use on either side of the repairs. I find necessary, as follows:

15,900	feet	12-inch	main	pipe, $2.80	$40,420
1,700	"	8	"	" 1.85	37,145
34,200	"	6	"	" 1.27	43,434
32,800	"	4	"	" 83	27,224
13,500	"	2	"	" 40	5,400
98,100	"	Total, or 18 55/100 miles			119,722
		Add 144 hydrants, at $60			8,640
					$128,363

The prices are for pipe laid, and include all labor, material, gates, joints, fourways, etc., and is approximate, but safe, and sufficiently near to estimate the rest of the work as a whole. I have estimated on cast-iron pipes, but advise the use of the iron pipe lined and encased in cement, as having been used for over twenty-five years with success in a large number of towns, costing less in first outlay, delivering the water as pure as from the source, and avoiding the loss of calibre found in cast pipes, arising from tubercles and incrustations due to chemical action of some waters on iron. As the cement is practically indestructible, the pipes are, as now made, capable of enduring for any time.

The question of income is one very difficult to estimate satisfactorily, and each person may honestly widely differ in anticipating a result. I have counted the houses of various sorts, and find on the line of pipes as proposed 859 dwellings and stores. I have assumed that as a well costs at least an average of $100, no man should decline to pay the interest of $7 for the use of water carried to him, and make this charge the lowest. The other charges I have adopted after examining various cards of water rates sent to me from various localities. The amounts are as follows:

240	private dwellings,	@ $7	$1,680
150	" "	@ 10	1,500
150	" "	@ 15	2,250
50	" "	@ 25	1,250
10	" "	@ 50	500
3	hotels,	@ 500	1,500
5	livery stables,	@ 25	125
3	bakers,	@ 25	75
110	stores and saloons,	@ 10	1,100
2	factories,	@ 250	500
United States Lighthouse Department			280
American Docks			500
Building purposes			500
			$11,730

THE RAISING OF THE VANGUARD.

THE attempt to raise the Vanguard is now on the eve of being made, but some preliminary arrangements are still necessary before it can be commenced. The advertisement for tenders on the part of the Lords of the Admiralty in December last elicited more than 450 replies, and a contract for raising the vessel has been entered into with a French civil engineer, who has for a considerable time been resident in England. The method he proposes to adopt is as follows: Caissons are to be used having a measurement of ten feet in diameter and eleven feet in length. They are to be provided with two rings at the top and bottom, and to each of the lower rings there will be about two feet of chain, having a hook attached. These chains and hooks are to be used to facilitate the attaching process to the Vanguard. The contractor intends to attach the caissons to any good holdfast, such as port-holes, etc., and as the ship is now lying upon her starboard side, at an angle of about 70 deg., he further intends to right her and to pass a chain round her, going under her stern and stern-posts, and joining so as to make a cradle. This chain he will attach to the caissons. In the interior of the ship about 2000 air-balloons will be placed, each having a lifting power in water of one ton. The first work of the divers below water will be to attach the caissons by the chains to the vessel, until a sufficient number of caissons has been lowered to float the ship. Of course she will only rise gradually, so the contractor intends to draw her to shallow water, and when he has brought her 60 feet, or thereabouts, from the level of the sea to her keel, he will lower a floating-dock and catch her. The method has never been tried in practice, and we hope it may prove successful. The agreement which the Admiralty has entered into contains the following clauses:

Whereas her Majesty's ship Vanguard now lies sunk at a distance of eleven miles, or thereabouts, from the coast of Ireland, and of 16 miles, or thereabouts, from Kingston harbor, in Ireland aforesaid, and an offer to raise the said ship has been made by the said contractor. Now it is hereby covenanted and agreed between the commissioners for themselves and their successors in office and the contractor for himself, his heirs, executors, administrators, and assigns, as follows:

1. For the purpose of this agreement all such boats, anchors, cables, rigging, gear, spars, guns, shot, shell, ammunition, money, effects, and things as are not of the nature of permanent fittings and fixtures, and can be recovered without cutting, breaking up, or materially injuring the fabric, compartments, or decks of the said Vanguard, are included in and referred to by the term "stores," and the complete hull and fabric of the said Vanguard, with all plate, engines, boilers, machinery, and permanent fittings and fixtures and things not included in and referred to by the term "ship."

2. The Lords Commissioners, or any officer appointed by them, are to have free access at all times during the operation of raising.

3. The hull must be delivered whole and entire, not cut or broken, except what was done by the accident, the stern-post, no doubt, having suffered from the shock when it struck the ground.

4. Operations are to be commenced as quickly as possible, and carried on with due diligence whenever the weather allows.

5. No assistance is bound to be given, but should the contractor require anything which the Admiralty have at their disposal the contractor is at liberty to have same, paying for it at a reduced rate.

6. On all the stores saved, as per Article 1, salvage will be paid.

7. The contractor is at liberty to have any dry-dock without paying for same, provided he raises the Vanguard, and the Admiralty will dock her, but at expense and risk of the contractor.

8. The contractor is responsible for any patent-rights which he may infringe upon.

9. The agreement can not be transferred to any other party without the permission of the Lords of the Admiralty.

10. The inspector appointed to watch the operations, should he disapprove of any procedure on the part of the contractor, may give him notice to discontinue the work, and if after the Admiralty wish all operations are to cease, and the plant removed.

11. Also, should the Admiralty find the *modus operandi* inapplicable, they are at liberty to cancel the agreement.

12. If the contractor fails to carry out his agreement, through one of the above articles or any other cause, the Admiralty are at liberty to continue the operations and use any patent or method the contractor has been using.

The contractor, if the weather permits, has arranged to start in a fortnight for the scene of the disaster, and we understand that an English engineer will have the entire superintendence of the work, which will commence in earnest in the first week of May. The caissons are to be made of iron, as they are to have air pumped into them to 3 atmosp., so as to counterbalance the pressure of the water. The operations will be carried on with great difficulty, as it is very dark at the depth of 19 fathoms. However, it is intended to try electric lights as well as submarine lamps. In November the Vanguard was 8 feet 6 inches in the sand, and since then we understand that more sand has drifted round her.

NEW ICE MACHINE.

IN this machine the temperature is reduced by the expansion of sulphurous-acid gas. This body is liquid under the atmospheric pressure at a temperature of −10° C., and it does not give pressures higher than four atmospheres at a temperature of 35°. This liquid does not act on metals or fats; it is not combustible, and is the least expensive of all known volatile liquids. By the process of manufacture discovered by M. R. Pictet, it costs less than sulphuric ether.

Thus, by taking advantage of the general principle of the evaporation of a volatile liquid to produce cold, and utilizing sulphurous acid, we can obtain a machine which gives results constant in every country, and which acts in a perfectly mechanical and normal manner in all latitudes. The following is a brief description of a typical machine manufacturing 250 kilogrammes of ice per hour:

A cylindrical tubular copper boiler has a length of 2 metres and a diameter of 35 centimetres; 150 tubes of 15 millimetres traverse its entire length, and are soldered by their extremities to the two ends. This first boiler is the refrigerator. It is placed horizontally in a large sheet-iron vat, which contains 100 tanks of 20 litres each. An incongealable liquid, salted water, is constantly circulating in the interior of the refrigerator by means of a helix. This liquid is re-cooled to about −7° in a normal course, and it licks on its return the sides of the tanks which contain the water to be frozen.

In the space reserved between the tubes of the refrigerator, the sulphurous-acid liquid is volatilized, its vapors are drawn up by an aspirating force-pump, which compresses them without the condenser. This condenser is a tubular boiler, the same as the refrigerator; only a current of ordinary water passes constantly into the interior of the tubes to carry off the heat produced by the change of the gaseous into the liquid state of the sulphurous acid, and by the work of compression. A tube furnished with a gauge tap, adjusted by the hand once for all, permits the liquefied sulphurous acid to return into the refrigerator to be subjected anew to volatilization.

Sulphurous acid has the exceptionally advantageous property of being an excellent lubricant, so that the metallic piston which works in the cylinder of the compressing pump requires no greasing. Thus the introduction of foreign matter into the apparatus becomes entirely impossible.

The work necessary to manufacture 250 kilogrammes of ice per hour is at the most seven-horse power.

A cold of 7° in the bath is amply sufficient to obtain in the tanks a rapid and in every way economical congelation.

With these mechanical arrangements the following important advantages are realized: 1. The pressure never exceeds

four atmospheres. 2. There is never any entry of air to fear, the pressures, as far as —10° C., being always above that of the atmosphere. 3. The volatile liquid employed is perfectly stable, undecomposable, and without chemical action on metals. 4. All greasing in the machine is dispensed with. 5. The volatile liquid is obtained at a very low price, and it is accompanied by no danger of explosion or fire. 6. The cost of production of the ice approaches infinitely near to the theoretic minimum: it is about 10 francs ($2) per ton of ice.—*Nature.*

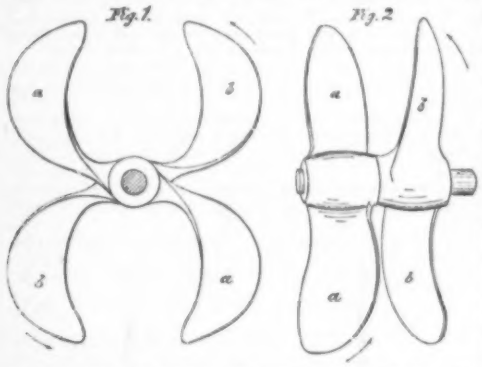
THE COLLIS BROWNE SCREW-PROPELLER.

CONSIDERABLE attention has of late been drawn in England to the remarkable performances of Dr. Collis Browne's propeller, and to certain peculiar forms proposed by him for the hulls of war vessels. His propeller, which has been patented in this country, is represented in the above engraving, and may be described as follows:

The invention consists in the arrangement of two independent screws, or sets of blades, having their like faces reversed with respect to each other.

Fig. 1, front elevation; Fig. 2, side elevation; Fig. 3, perspective, showing the screw applied to a vessel.

a and *b* are the blades of the screw, which are, as represented, formed with a transverse curvature, so as to present on



one side a concave surface and on the other a convex one. The blades taper from their centres to their extreme ends, which are pointed, and are curved slightly inward or toward the axis.

It will be observed that the blades are formed in pairs, and that each pair projects from a separate hub. The pairs are alike in form, but are relatively reversed in position on the shaft, or turned toward each other, so as to present like faces in opposite directions, or unlike faces in the same direction, as shown in Fig. 1, where the convex faces *a a* and concave faces *b b* point in the same direction, the concave faces of each pair of blades pointing toward or opposite each other.

Referring to Fig. 2, one pair or series of blades is set fully before the other, so that each pair revolves in separate parallel planes.

This improved arrangement and construction of blades results in an increase of speed, a saving of power, and an avoidance of the tendency of the common propeller to force the vessel to one side. It also avoids the vibrations produced by the common propeller, and secures equal efficiency in whichever direction the screw is rotated, thus enabling the vessel's motion to be quickly checked and reversed, when desired.

The London *Standard* gives the following particulars of its performances:

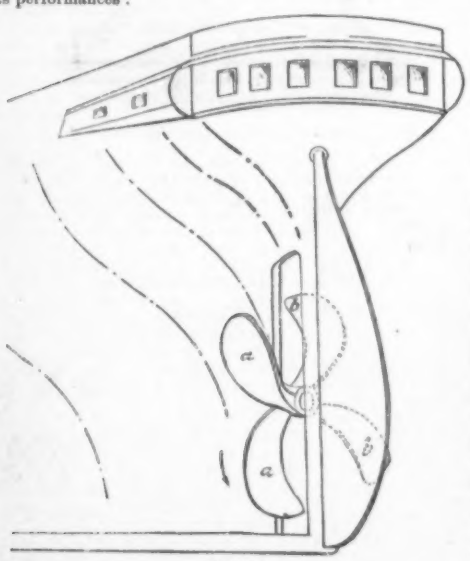
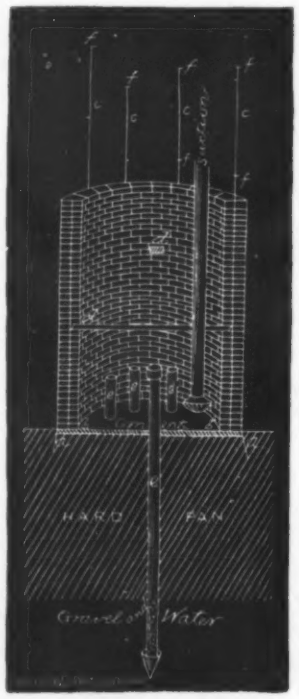


FIG. 3.

Dr. Collis Browne has invented and made successful trial of a four-bladed screw-propeller which is essentially peculiar. In appearance it is rather paradoxical, for it resembles two double-bladed screws on one shaft, one screw being the exact reverse of the other. Hence it might be argued that one screw would neutralize the other, and all the power applied to effect the rotation of the propeller would thus be thrown way. But closer attention shows that the effect must needs be otherwise. When the propeller rotates each of the four blades is driving, two with their faces and two with their backs, these latter receiving the water thrown from their foremost pair. There is a powerful grip on the water, and at the same time the action is smooth, steady, and silent, never "thrashing" or producing vibration. The water is, as it were, wormed through the screw in a uniform thread, one continuous stream being thrown aside from the centre of the propeller in a direct axial line. The power of this propeller is indicated by the quickness with which it stops a vessel when the motion of the screw is reversed. This occurs even with the screw fitted to the stern in the usual way. A steamship of 1043 tons register was fitted with one of these propellers, 12 feet in diameter. When steaming at about ten knots an hour the vessel was stopped in her own length on the motion of the screw being reversed. A little yacht, 60 feet long, fitted with one of these propellers, having a diameter of 3 feet 6 inches, was in like manner stopped in a few seconds when steaming from 15 to 16 miles an hour, and in sixteen seconds from the commencement of the reversal was going astern. This boat was the Cicada, well known in the Royal Yacht Squadron, and was originally built for Mr. Moens. A Collis Browne propeller was fitted to a steamboat belonging to the Thames Conservancy. The screw previously used was 2 feet 4 inches in diameter. By some mistake the Collis Browne propeller was made with a diameter of 1 foot 10 inches. It appeared ridiculously small for its work; but, nevertheless, trial was made of it, and to the surprise of all parties it was found to propel the boat very nearly if not quite as fast as the larger screw. Reports of an official nature, both at home and abroad, testify very strongly to the good qualities of the invention. Among other points the propeller is credited with maintaining the speed of the vessel to which it is applied with a considerable reduction in the consumption of fuel, as compared with other propellers. A Trinity House report speaks of a saving in fuel to the extent of 25 per cent. The absence of vibration, and the power of the screw in stopping a vessel, are points which also attract attention. The value of the latter quality in preventing collisions is obvious. One peculiarity of the screw is that it does not in any way affect the steering of the ship. If the helm be kept amidships the screw will drive the vessel straight on. As such an invention is calculated to be of public service it is satisfactory to know that a trial of the propeller is about to be made at Portsmouth, by authority of the Admiralty.

SYCAMORE, ILLINOIS, WATER SUPPLY.

WE illustrate below a simple and, in some respects, novel mode of construction for a water well, which, with some modifications, should be of value to numbers of our Western cities and corporations contemplating water-works or requiring such wells for other purposes. The dimensions given



SYCAMORE WATER SUPPLY.

are essentially those being adopted by the city of Sycamore, Ill., in connection with their admirable water-works otherwise just completed.

Wells previously sunk at this point had demonstrated the absence of rock and the presence of water at the depth of 70 feet. In locating this well, a preliminary boring of 3 inches diameter was made at slight expense till water was reached, and the various quantities of earth withdrawn were carefully noted. This boring, being satisfactory, was made the centre of the proposed well, which is 8 feet in diameter between walls, the walls being 8" thick, of brick laid in cement. In this instance, the nature of the soil permitting, an excavation was made to the depth of 20 feet before commencing the wall, when digging was suspended and the masonry laid to the surface of the ground. For the further depth contemplated, the wall will be settled as fast as laid and simultaneously with the laying. To facilitate the settling and to maintain the integrity of the structure in the process, the following devices were adopted, as shown in the sectional and partial illustration herewith given. A base piece was constructed consisting of a horizontal annular plate, *b b*, upon which the lower course of masonry is laid, to which plate was secured the nearly perpendicular flange, *a a*. This flange is of 3-16 iron, 8 inches deep, and flares outward about ¾ inch on all sides. This flange cuts its way downward under the weight of the wall as fast as the earth is removed, making a passage slightly larger than the structure itself. In the horizontal base are secured six ¾ upright bolts, *c c*, each 20 feet long and provided with several shoulders as shown at *f f*. These bolts are imbedded in the wall as it rises.

For the purpose of further strengthening the wall, horizontal wooden braces, *d d*, extending from one side of the wall to the other, are inserted at intervals, their ends being imbedded in the masonry.

At Sycamore, several feet of hardpan are encountered at a depth of 55 feet, and upon this the wall will rest. From this point water will be reached by a number of additional borings about the central tube, originally inserted, and tubes introduced to the gravel stratum. These tubes will project about 3 feet above the bottom, and the pump suction will extend somewhat below their tops, so that when it is necessary to clean the well, the water may be drawn down, the tubes capped, and cleaning effected. The well bottom will be finished in cement.

The pumps are located about 25 feet distant, and set 25 feet below the surface. On the level with the pump foundations the water and pump wells will be connected by a tunnel through which the suction and relief pipes will be laid, after which it will be securely closed.

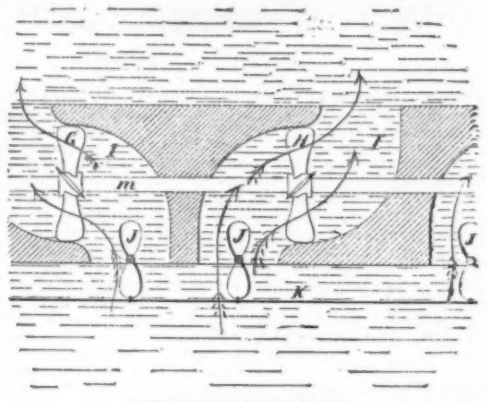
The more novel features presented in the above construction are to be credited to the suggestions of the local committee, who, after their experience, will be able and doubtless willing to afford valuable hints to others investigating the same subject.

The works at Sycamore are mainly designed to secure fire protection to the business portion of the city. The standing contents of the well will be about 13,000 gallons, and the flowing supply, as approximately shown by the tube first sunk, can be made far more than adequate to meet all possible demands. A splendid pair of Blake's Direct Acting Steam Pumps, 16 x 8 x 24, taking steam from the capacious boiler of the Marsh Harvester Works, are in place. The works were put in by T. B. Farrington, of Chicago, and are in every respect complete and effective.—*Engineering News.*

IMPROVEMENT IN TIDE-POWERS.

By A. MALLORY, Mystic Bridge, Conn.

THROUGH the mill extends a horizontal shaft, on which are mounted a considerable number of small screw-propellers, in two sets. One set, G, is right-handed; the other set, H, is left-handed. Curved pen-stocks I, formed of masonry or other suitable material, receive the water from the high-level, and discharge it into the low-level. J J are peculiar gates, analogous to butterfly-valves, operated by a single rod, K, controlled by the attendant at the mill. The gates J, being properly adjusted, by their opening and closing give greater or less freedom to the flow of the water. In the best condi-



NEW TIDE-WATER POWER.

tion of the apparatus the valves J stand wide open, and the water is allowed to flow freely, except that it is given a slight helical motion by flowing past the twisted gates J. In passing the screw-propeller, the current of water imparts a rapid rotatory motion thereto, and receives from the inclined position of the blades of the screw-propeller a tendency to a helical motion in the direction opposite to that of the rotation of the screw. This, in the best condition of the apparatus, is only just sufficient to neutralize the effect of the helical motion in the other direction, which it received in passing the gate J, and the water is consequently discharged into the lower level without any considerable twisting motion.

THE KENTUCKY SHOWER OF FLESH.

AT last we have a proper explanation of this much talked of phenomenon. Mr. L. Brandeis writes to the *Sanitarian*, for May:—

In 1537, while Paracelsus was engaged in the production of his "elixir of life," he came across a very strange-looking vegetable mass, to which he gave the name of "Nostoc."

The want of rapid transportation, combined with the perishable nature of the substances fallen, have hitherto prevented a complete and exhaustive examination. The specimens of the "Kentucky shower," however, reached this city well-preserved in glycerine, and it has been comparatively easy to identify the substance and to fix its status. The "Kentucky wonder" is nothing more or less than the "Nostoc" of the old alchemist. The Nostoc belongs to the confervæ; it consists of translucent, gelatinous bodies, joined together by thread-like tubes or seed-bearers. There are about fifty species of this singular plant classified; two or three kinds have even been found in a fossil state. Like other confervæ, the Nostoc propagates by self-division as well as by seeds or spores. When these spores work their way out of the gelatinous envelope they may be wafted by the winds here and there, and they may be carried great distances.

Wherever they may fall, and find congenial soil, namely, dampness or recent rain, they will thrive and spread very rapidly, and many cases are recorded where they have covered miles of ground, in a very few hours, with long strings of Nostoc.

On account of this rapidity of growth, people almost everywhere faithfully believe the Nostoc to fall from the clouds, and ascribe to it many mysterious virtues. The plant is not confined to any special locality or to any climate; sown by the whirlwind, carried by a current of air, in need of moisture only for existence and support, it thrives everywhere. Icebergs afloat in mid-ocean have been found covered with it. In New Zealand it is found in large masses of quaking jelly, several feet in circumference, and covering miles of damp soil; and in our own country it may be found in damp woods, on meadows, and on marshy or even gravelly bottoms.

All the Nostocs are composed of a semi-liquid cellulose and vegetable proteine. The edible Nostoc is highly valued in China, where it forms an essential ingredient of the edible bird-nest soup. The flesh that was supposed to have fallen from the clouds in Kentucky is the flesh-colored Nostoc (*N. carneum* of the botanist); the flavor of it approaches frog or spring-chicken legs, and it is greedily devoured by almost all domestic animals.

Such supposed "showers" are not rare, and are entirely in harmony with natural laws. In the East Indies the same Nostoc is used as an application in ulcers and scrofulous disease, while every nation in the East considers it nourishing and palatable, and uses it even for food when dried by sun heat.

THE CRYSTALLIZATION OF METEORIC WATERS.

M. GASTON TISSANDIER has recently presented to the French Academy of Sciences an interesting communication relative to the saline matters contained in snow and rain water, and the remarkable crystallizations revealed by the microscope on their being evaporated. These crystals are for the most part formed by the nitrate of ammonia, which is abundantly contained in meteoric waters, and they are remarkable for their singularity of form. It is merely necessary to evaporate a drop of rain or snow water on a plate or glass in a warm place to discover these crystals, which are, however, most numerous in first rains or snows after periods of fair weather.

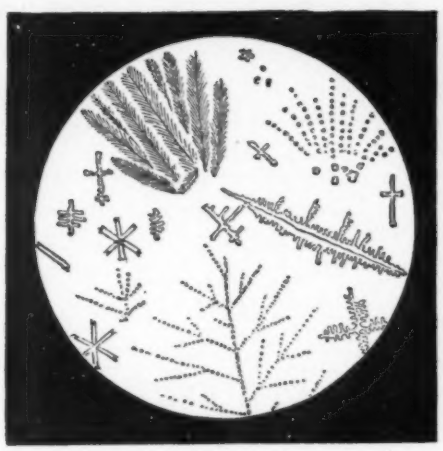


FIG. 1.—RAIN-WATER CRYSTALS.

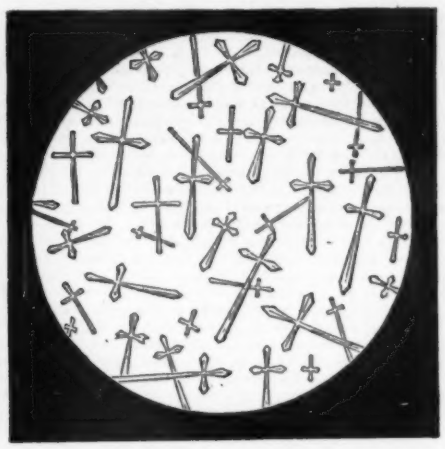


FIG. 2.—SNOW-WATER CRYSTALS.

In Fig. 1, which we extract from *La Nature*, is represented rain-water crystals magnified 500 diameters; some resemble the most delicate feathers, others hexagonal crosses, others again are curiously irregular or branching in shape. They are very deliquescent, and promptly disappear under the influence of moist air.

Fig. 2 shows remarkably beautiful crystals found in snow-water, and the odd sword-like or cross-shaped forms are often assumed by nitrate of ammonia in meteoric waters.

M. Tissandier states that he has attempted many times, though fruitlessly, artificially to produce these crystals by evaporation of the salt. The only forms he has obtained have been branches depending from a single stem. He attributes the peculiar crystallization above noted to the organic matter contained in the rain and snow, which he considers worthy of especial investigation. He has remarked that in separating the meteoric water from sediment there has always settled at the bottom of the containing vessel a substance strongly resembling coagulated albumen. It is the organic material which he thinks exercises some influence on the crystallizations.

[Condensed from La Nature.]

THE DISCOVERY OF GALLIUM.

ON the 27th of August, 1875, a French scientist, M. Lecoq de Boisbaudran, found evidences of the existence of a new simple body, in the products of a chemical examination of a blende derived from the mine of Pierrefitte, in the valley of Argelès (Pyrenées). This discovery was not the result of accident, as might be supposed, but was due to long researches carried on over a period of fifteen years by M. Lecoq, with the object of establishing a new method of investigation of hitherto unknown elements—a method which the author intended to publish later, and in which spectrum analysis did not play an indispensable part. However this may be, M. Lecoq availed himself of spectrum analysis in examining the metallic solutions of blende, submitted to the action of the relative spark. He then saw flash into existence a new spectrum characterized by two bands, both situated in the violet, the disposition of which is clearly shown in the annexed engraving, Fig. 1. The upper scale is added to allow of comparison of the gallium lines with those of other metals.

In order to make this spectrum analysis, M. Lecoq used various apparatus, representations of which are given in Figs. 2 and 3. In Fig. 2 at 1 is shown a spectral tube mounted on a flat cork; *a b* are the electrodes, and *c* is the liquid to be examined, at the surface of which the electric spark passes. 2 is the spectral tube shown singly, in order to exhibit how the platinum wire electrode is fastened at the bottom. 3 is a very small tube designed to be completely filled with the liquid—the spark then passes just at the summit of the lenticular surface. This was used only in exceptional cases. In 4 is a very small tube, a little higher than the preceding. It contained but a single drop of liquid, and was employed in connection with very short sparks. The apparatus shown at 5 included a U tube filled with the liquid, the wires leading to the surface in each leg. 6 shows the tube employed ordinarily. Its interior diameter is 1 centimetre to 13 millimetres, height 2 to 4 centimetres. 7 is a large tube conical at its lower end, available for either large or small quantities of liquid. The electrode is here soldered in a tube of glass which traverses the cork in the mouth of the larger tube.

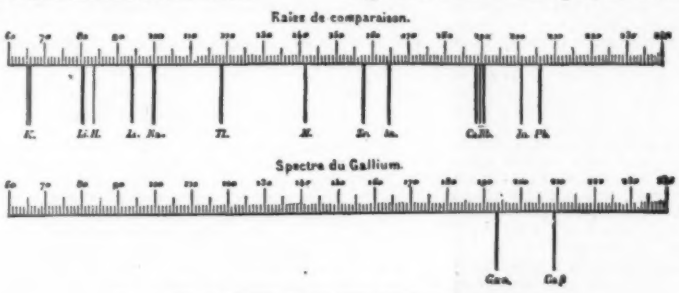


FIG. 1.—THE SPECTRUM OF THE NEW METAL, GALLIUM.

Fig. 3 exhibits the arrangement of the complete apparatus. A is a cork attached to the support D, and sustaining a platinum rod F of 1 millimetre diameter. C is a small glass tube containing the liquid, as already described. B is a large piece of cork, serving as a holder. G is a hook of platinum wire, 0.5 millimetre in diameter, traversing the tube C, and forming an electrode. The liquid employed by M. Lecoq, was principally chloride of gallium—in a concentrated state—and in no case were other lines than those previously noted observed. These the discoverer accurately distinguishes as follows:

α 193.72	417.0	Narrow, strong. Notably more brilliant in a spark of medium length than in a very short spark.
β 208.09	403.1	Narrow; well marked, but much less strong than α 193.72. Notably more brilliant with a medium than with a very short spark.

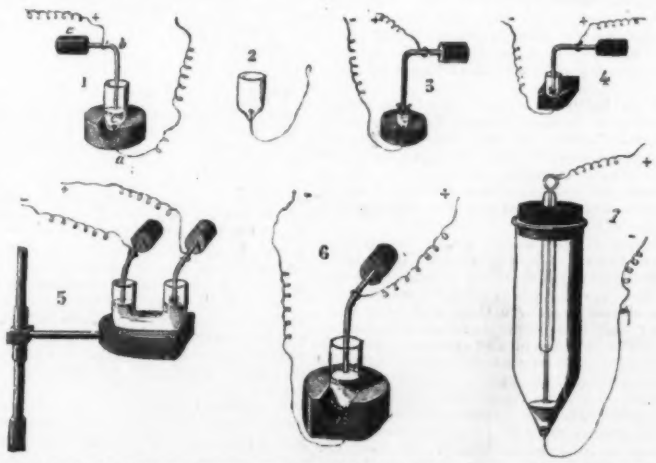


FIG. 2.—TUBES FOR THE SUBMISSION OF GALLIUM SOLUTIONS TO THE ELECTRIC SPARK.

The line α 417.0 is characteristic of gallium; it is a very sensible reaction.

Proceeding chemically to the examination of his discovery, M. Lecoq investigated the reaction of the salts, and observed that the sulphide, mixed with a large amount of sulphide of zinc, is insoluble in an excess of sulphydrate of ammonia. He further recognized that the salts of the new metal are precipitated (cold) by carbonate of baryta, and that the metal itself is precipitated by sulphydrate of ammonia.

Finally, at the meeting of the French Academy of Sciences, of December 6th, 1875, M. Wurtz presented a specimen of metallic gallium, and gave a complete history, so far as was practicable, of the nature and properties of the new body. The substance of M. Wurtz's communication has already been given in the SUPPLEMENT, and it is unnecessary to repeat it other than in the shape of a brief review here, in connection with other reference. The sulphate of gallium dissolved in an ammoniacal water was submitted to the action of a voltaic current, and the gallium was deposited in a metallic state on the platinum plate, which was the negative electrode. The specimen presented to the Academy weighed 34 milligrammes, and had been deposited in 5 hours and 40 minutes, on a surface of 123 square millimetres. It appeared of a brilliant white—somewhat brighter than platinum.

When the gallium salt is slowly decomposed by a carefully regulated current, the metal is deposited in a fine surface, delicately granulated, and filled with brilliant points, of which the microscope shows the crystalline structure. Gallium decomposes water (cold) under the influence of hydrochloric acid, and the reaction, much more energetic under the action of heat, is accompanied by a strong disengagement of hydrogen.

M. Lecoq has noted the existence of the metal in a large number of zinc ores, and believes that it may be found in all the blendes. It is, in fact, necessary to treat ores in order to obtain the metal, for large quantities of metallic zinc have been examined for it without success. It is only met with, in any case, in very small quantities, and its discovery adds another example of the extreme sensibility of spectrum analysis.

M. Lecoq has prepared a certain number of gallium salts, and notably a crystallized substance, which appears to be the alum of the new metal. This fact, if it is well established, is of considerable importance, for it will fix incontestably the atomicity of the element by indicating that the oxide of gallium has a chemical function analogous to that of aluminum, and that the formula is $Ga^2 O^3$. On the other hand, gallium strongly resembles zinc, as, like it, it is only precipitated from its solutions by sulphuretted hydrogen under the influence of acetic acid.

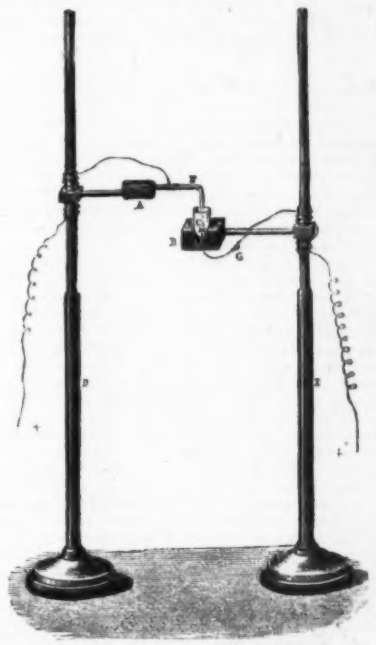


FIG. 3.—APPARATUS FOR THE SPECTRUM ANALYSIS OF GALLIUM.

NEW RAYS OF CALCIUM.

MR. LOCKYER, in a letter to M. Dumas, says: I have recently carried out a series of experiments upon calcium, employing at first a small battery and a small coil, and afterwards a large battery and a larger coil, and to avoid all doubts I photographed the results. I found that with the small coil I was able to obtain a photograph which only contained the ray in the blue, without any trace of the ray in the violet; and with the largest battery and the largest coil I obtained a photograph containing the rays of the violet without any trace of the ray in the blue, and that by varying the surface of the battery I was able to get a spectrum resembling the absorption-spectrum of calcium in the sun.

These results agree so completely with those of the dissociation of a salt of calcium that I have asked myself the question if we have not here before us a dissociation of calcium itself. Naturally we are unable to determine, for the present, whether we have a lower molecular group of calcium, or whether the calcium itself is a compound of two distinct sub-elements, if the expression may be used. It seems that we can only undertake to solve this question by photographing the rays of calcium (H_1 H_2) in different stars. If we find that they present always the same relative breadth and intensity there will be a strong presumption that we have met with a decomposition of calcium, or, in other terms, we shall have shown that a spectrum of rays is a spectrum due to different orders of molecular grouping. If, on the other hand, we find that these lines vary in breadth and in intensity, it will be difficult to explain this phenomenon except we admit that calcium, instead of being an element, is really composed of two substances.—*Comptes Rendus.*

MR. W. SAVILLE-KENT, F.L.S., F.G.S., etc., formerly of the British Museum, and more recently of the Brighton, Manchester, and Yarmouth Aquaria, has been appointed Managing Naturalist to the Royal Aquarium, Westminster. Some of the fresh-water tanks are already stocked with fish; the sea-water is being rapidly imported, and it is anticipated that a fine collection of both salt and fresh water species will be on view in the course of a few weeks.

STUDIES OF MATTER AND LIFE.

By HENRY J. SLACK, F.G.S., Sec. R.M.S.

THE discoveries of recent science have greatly affected the notions we are able to form concerning the relations of force and matter, and likewise of the connection between physical agencies and manifestations of life. In studies of this description we are struck with the amount of force that lies potentially in extremely minute quantities of matter ready for vigorous action the moment the right stimulus is applied, and by the way in which quickness of motion makes up for smallness of weight. The physical inquirer is not obliged to tarry for the curious and important investigations of the metaphysician; he need not attempt to settle the fundamental questions—what is matter? and what is force?—in the ultimate constitution of either. To the experimentalist, matter is known by what it does; and whether the problem before him relate to mechanics, chemistry, electricity, light, heat, or gravitation, it is with matter in motion and exhibiting force, because in motion, that he has to deal. The same may be said of all the physical processes and manifestations of life, though we seem no nearer than the ancient Greeks were when we try to understand the connection between motions of particles and the phenomena of feeling and thought.

MODES OF MOTION.

Light, heat, electricity in its various forms, chemical force and nerve force, are not only now classified as "modes of motion," but the motion in each manifestation of these forces appears to be wave motion; and it is probable that gravitation, the correlation of which with other forces is not yet established, may at last be found to be a wave motion also. In wave motion each particle moves, pendulum-wise, backwards and forwards in a small curve, transmitting the motion to the particles before it in more or less rapid succession, the motion becoming weaker as the original impulse is divided amongst more and more particles, until at last it is so enfeebled that it can not be observed. The common illustration of throwing a stone in a still pond and watching how, as the outward circling wavelets spread, they grow weaker and weaker, and if the space is large enough, at last seem lost in the calm beyond—this affords a good notion to begin with of wave forms and wave force; but suppose, instead of a stone striking the surface of water, a sudden explosion took place of a particle of dynamite at some depth below. Here we should have waves in all directions, ascending, descending, and spreading on every side. Such waves would bear somewhat the relation to the pond-waves that a well-known toy composed of balls within balls would do to a mere section of the whole concern. Wave beyond wave in consecutive series, spreading in all directions from a point, must be conceived as spherical shells one outside the other like the coats of an onion, each expanding and contracting within narrower limits, and sending the wave force and the wave form onwards to an indefinite extent.

The quantities of matter acted upon by these wave forces may be very small, and yet the power exerted very great. Thus "Faraday found the quantity of electricity disengaged by the decomposition of a single grain of water in a voltaic cell to be equal to that liberated in 800,000 discharges of the great Leyden battery of the Royal Institution. This, if concentrated in a single discharge, would be equal to a flash of lightning. He also estimated the quantity of electricity liberated by the chemical action of a single grain of water on four grains of zinc to be equal in quantity to that of a powerful thunderstorm." * Tyndall himself also beautifully illustrates this subject in his remark: "I have seen snow-flakes descending so softly as not to hurt the fragile spangles of which they were composed; yet to produce from aqueous vapor a quantity which a child could carry of that tender material, demands an exertion of energy competent to gather up the shattered blocks of the largest stone avalanche I have ever seen, and pitch them twice the height from which they fell."†

When galvanic electricity is employed to decompose water, the constituent elements, oxyen and hydrogen, are not merely *allowed* to separate, but they are pulled apart with great force, and Gassiot showed that if the water were confined in iron bottles an inch thick, a small battery gave force enough to split them asunder. The directive force which the particles of water obey in the act of freezing, and which leads to its expansion, has similar power; and, as is well known, a very small quantity of water will burst a strong shell or split a great rock.

THE ETHER OF SPACE.

Although heat sets the molecules of all sorts of matter in motion, not purely wave motion, it comes to us in a wave motion from the sun, conveyed like light by a material so attenuated as almost to reach the supposed condition of spiritual existence. This ether of space, which we can neither see nor feel, approximates to the conception, if such can be formed, of an immaterial subject. It must be so thin, and so light, that an inconceivable quantity would be required to weigh a pound, and yet when in motion the marvellous speed of its oscillations enables it to exert gigantic force. It can act so mildly that we are utterly unconscious that any substance strikes our eye when we see, or have a sensation of, violet light, in consequence of 700 million millions of its minute waves dashing against it in a second. But light can also cause chlorine and hydrogen to rush together with enormous force, and it can instantly tear to pieces chemical compounds held together by forces equivalent to prodigious mechanical powers.

Professor Josiah Cooke reckons that if this ether (of whose existence he is not quite satisfied) were as dense as common air, it would resist pressure on each square inch of seventeen million million pounds, just as air balances one of about 15 lbs. without suffering compression. He also tells us that if we could confine ether in a cylindrical vessel of sufficient strength to bear the pressure, and put upon it "a cubic mile of granite rock, it would only condense the ether to about the same density as that of the atmosphere at the surface of the earth." ‡

In consequence of its wonderful elasticity, ether can convey light waves about a million times quicker than air can convey sound waves, and some of the pulsations that reach us from the sun, and which lie beyond the violet end of the visible spectrum, must make their extremely short wave oscillations much quicker than the 700 millions of millions of violet light. Should, contrary to probabilities, the theory that space is filled with ether, and that ether has the properties mentioned, be ultimately found untenable, the measures of wave lengths and wave velocities must still refer to something positively existing. Light comes to us from the sun at the rate of about 190 * millions of miles in a second, whatever it is; and when physicists say a wave of red light is about $\frac{1}{39000}$ of an inch long, and a violet one about $\frac{1}{57000}$ long, no doubter of the existence of ether, like Professor Cooke, hesitates to assume that they are quantities of something. The probabilities are, however, enormously in favor of the theory that ascribes certain properties to ether, and that light and heat consist in its undulations. All known facts coincide absolutely with this theory, and it has been the means of leading physicists and mathematicians to fresh discoveries.

What is this ether, that it possesses properties so extraordinary, and that, to speak in common language, a mere nothing of it in point of quantity can be the source or the vehicle of enormous powers? Professor Tyndall says it must be a material substance, but perhaps not a form of ordinary matter. If it is composed like common matter, its particles or molecules do not touch; and in that case it will be difficult to avoid the belief that there is a still more subtle kind of matter filling up the interspaces. If it be matter not divided into atoms or molecules, but continuous, we may expect to find that it will exhibit many properties and peculiarities not yet discovered, differentiating it from matter in ordinary forms.

Faraday followed Newton in feeling an invincible objection to the notion that matter could act through empty spaces, and, as we find in his life by Dr. Bence Jones, he was fond of quoting the following passage from a letter of Newton to Bentley:—"That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a *vacuum*, and without the mediation of anything else, by and through which this action and force may be conveyed from one to another is to me so great an absurdity, that I believe no man who has, in philosophical matters, a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."

Faraday's own views on this subject were never very clear to other people. He recognized "lines of force," and spoke of "atoms" as centres of force, and not as so many little bodies surrounded by forces. The force was the atom extending indefinitely in all directions. According to these conceptions, "water is not two particles of oxygen (and hydrogen) side by side, but two spheres of power mutually penetrated, the centres even coinciding." † In the same place he said, "The force or forces constitute matter; there is no space between the particles distinct from the particles of matter."

TRANSMISSION OF WAVE FORCES.

We need not for present purposes pursue these speculations further. The wave forces mentioned communicate immense velocities to the molecules of matter, and these velocities are, in fact, their powers. A gas—or common air, which is a mixture of gases—resists pressure and exerts pressure, because its particles are in vigorous, rapid, and ceaseless motion. Substances that are translucent, or transcalorescent, are so composed that ether waves go through them as water goes through a sieve. Bodies that do not allow light or heat to pass in this way, have their molecules set in motion by the impulse of the ether waves, and thus new forms of force are generated.

Tyndall's beautiful experiments on the powers of various substances to absorb heat and stop its radiation offer most instructive instances of the power exerted by small quantities of matter. Taking the absorption of one atmosphere of common air to be unity (1), it was found that this power was augmented thirty-fold when the same quantity of air was permeated by a little vapor of patchouli; lavender vapor raised it to 60 times, camomiles to 87, cassia to 109, and aniseed to 373. Upon these results Tyndall remarks "that the number of atoms in the tube (experimented with) must be regarded as almost infinite in comparison with those of the odors. . . . . It would be idle to speculate on the quantities of matter implicated in these results. Probably they would have to be multiplied by millions to bring them up to the pressure of ordinary air. Thus—

> The sweet South
> That breathes upon a bank of violets,
> Stealing and giving odor,

owes its sweetness to an agent which, though almost infinitely attenuated, may be more potent as an intercepter of terrestrial radiation than the entire atmosphere from bank to sky." ‡

Wherever we find power exhibited, matter is in motion, and if the quantity of matter is infinitely small, and yet the power great, it is because the motion is infinitely quick. The waves of chemical force streaming from the sun are very short, and the quantity of matter acting in each oscillation, and tapping at the molecules on which it acts, is inconceivably minute, but the taps are as inconceivably numerous and rapid. They are also rhythmical, and we know how the stone walls of a large building may be set in vibrating motion when an organ tone of the right pitch impels air waves to go on tap, tap, tapping till the whole fabric shakes.

We learn from these and similar facts that the wave forces can give great powers to infinitesimally small portions of matter, and that, as we are not able to place any limit that we can comprehend to the possible velocities of atoms and molecules, so we are not able to assign any limit to the minuteness which would be incompatible with the exercise of effective force.

Becquerel has shown hat when a membrane is moistened on each side by a different liquid, an electric wave force is set up, able to effect chemical decomposition. Thus the minutest part of the minutest gland, or of the smallest organism that is capable of assimilating external matter, is enabled to change the chemical condition, and pull asunder molecules or atoms that would resist the mechanical force of a steam-engine or a hydraulic press.

Unfortunately, we have no chance of seeing the ultimate atoms or molecules of matter. Chemists use the term molecule to denote the smallest quantity of any substance capable of existing alone; but the definition is not quite satisfactory, because they have reason to believe there are many compound molecules that only exist in parts of more complicated combinations. Could we, by help of any apparatus, see ultimate molecules, the sight would be an astounding one; for an extremely minute portion of any substance, however solid and quiet it might appear to ordinary vision, would be exhibited to us as composed of infinitely more particles than all the stars we can perceive in a clear sky, and all in motions as harmonious as those of the celestial bodies. When either compositions or decompositions are going on we should see hosts, by the myriad, rushing together, or springing apart, as the case might be. Eternal motion is the condition of life, whether of the smallest unit or of the entire universe. Nature, as Humboldt said, is ever arranging herself in new forms, and absolute stillness would be cessation of being.

LIMITS OF VISION.—SIZE OF ATOMS.

The limits of visibility was one of the topics brought before the Royal Microscopical Society in February by the President, Mr. H. C. Sorby, in a remarkably able, and admirable, Annual Address.* Omitting the estimation of unavoidable errors in the construction of microscopical apparatus, and referring to researches by Pigott, Helmholtz, and Woodward, it seems that it is possible to distinguish the most favorable objects—alternate dark and bright lines such as in Nobert's test-plates—when they are as near each other as to be only $\frac{1}{112000}$ of an inch apart, provided that several circumstances, which need not now be explained, are favorable. Minute spherules of about $\frac{1}{80000}$ to $\frac{1}{100000}$ of an inch may also be seen if their refractive power differs sufficiently from the fluid, or other medium in which they are immersed. It may, however, be affirmed that few objects less than $\frac{1}{80000}$ of an inch in diameter can be seen; and of that size those only that are favorably placed. Mr. Sorby proceeded to inquire what sort of relation this power of microscopically assiste vision bears to the probable size of molecules of matter. He cited the results obtained by Stoney, Thompson, and Clerk-Maxwell, in attempts to calculate from different data the number of ultimate atoms in a given volume of any permanent and perfect gas at 0° C. and a pressure of one atmosphere. Thompson assigns as the greatest possible limit 98,320,000,000,000 in one-thousandth of an inch cube, which is $\frac{1}{100000000000}$ of one cubic inch. Clerk-Maxwell, estimating the true number indicated by the phenomena of the interdiffusion of gases, made it 311,000,000; and Stoney, from his point of view, 1,901,000,000,000. The mean of these numbers is 50,260,000,000,000. In a letter received by the writer from Mr. Sorby, since the publication of his address in the "Monthly Microscopical Journal" for March, he assigns double weight to Clerk-Maxwell's calculations, for reasons that we need not stop to explain, and considers the number of atoms in a cubic $\frac{1}{1000}$ of an inch of gas to be about 6,000,000,000,000, and that in the same space of liquid water the number of water atoms would be 3,700,000,000,000,000.

Water is essential to organic life: if an organism is thoroughly deprived of it, death ensues, though some creatures may be dried so as not to exhibit the least appearance of moisture, then pass into a dormant state, and become active again when more water and an appropriate temperature are supplied. The common rotifer and the *Anguillula tritici* have this property, and it is exhibited to some extent by that curious vertebrate, the Mud Fish, which survives an amount of drying that would be fatal to most animals as highly organized, though the baked mud in which it passes the hot dry season appears to prevent the desiccation from being carried too far for continuance of quiescent life.

MOTION AND FORCE OF ATOMS.

If we say water is so valuable to organic creatures on account of its dissolving so many substances they need to be supplied with in a fluid state, we may be asked why water has such power, and it seems probable that they depend upon the immense number of its molecules, as well as upon their mode of aggregation. Each atom or molecule in motion tends to set adjacent atoms or molecules in similar motion; and a great number of small impulses, rhythmically repeated, easily set considerable masses of such bodies in fresh motions, differing more or less from those which belong to their own constitution. A child with a little hammer, tapping at a great log of wood, will in time set all the particles vibrating, and though each particle may move only through a small fraction of an inch, when the whole log vibrates, the total quantity of motion is enormous, because the small motion of each particle is multiplied by millions and millions—that is, by all the particles the log contains.

Among the complex substances which chemists are acquainted with, no one could be named more important to organic life than albumen, which we all know in the condition of white of egg; and its remarkable powers of utility in the growth and development of plants and animals depends upon its extremely complicated structure. It contains a multitude of atoms of carbon, hydrogen, nitrogen, oxygen, and sulphur. It is usually found slightly alkaline; and some chemists, like Gerhardt, consider white of egg as a definite compound of an albumen acid with sodic hydrate, and believe other sorts of albumen have an analogous composition. Omitting, however, the alkali, Mr. Sorby takes as a probable composition of albumen C_{72}, H_{112}, N_{18}, SO_{22}: the letters representing the substance above named, and the figures the number of atoms which they contribute to the structure. With this view of albumen he finds that in a cubic $\frac{1}{1000}$th of inch of horn there are about 71,000,000,000,000 molecules of albumen. A molecule of this substance, though much larger than one of water, is far removed by its minuteness from any possibility of human vision; and as Mr. Sorby explains in his paper, light is too coarse a medium to enable them to be seen, even if we could add sufficiently to the powers of our microscopes.

GROUPING OF ATOMS.

When so many atoms of various substances are built up together to form a new substance, there is reason to believe that they are arranged in groups, each group having a definite constitution, and being a distinct entity, at the same time that it has an appointed place and a definite relation to the whole. Each group may be regarded as a system in which the atoms composing it are in ceaseless motion, exerting force upon their neighbors, and keeping within certain bounds, just as the planets do that circle round the sun. Each group acts as a whole upon other groups, and thus there are motions of groups as well as motions of atoms, subject to the same conditions of keeping within bounds.

Now, it is evident that the wave forces of which we have spoken have great opportunities of effecting changes in such complex structures. One form or mode of wave motion may strike with its myriad pulsations at a group of atoms, another may strike at certain atoms in the group, and by such means some atoms or groups may be thrown out of their courses, and then the rest may form a new pattern, or, if suitable atoms of another sort are at hand, may take them in to what may be called their social system, and modify it accordingly.

PHENOMENA OF REPRODUCTION.

The phenomena of the nourishment and growth of plants and animals depend upon actions of this sort brought about by the wave motions of heat, light, electricity, and so forth. Reproduction is, as Claude Bernard explains, intimately con-

---

* Tyndall, "Notes on Electricity," p. 15.
† "Heat as a Mode of Motion," 4th edit. p. 147.
‡ "The New Chemistry," p. 83.

* The exact distance can never be known, as some residual error is unavoidable. When all the Transit of Venus calculations are finished and compared with the experimental methods adopted in Paris, the average result will probably be not far from 190 millions.
† "Life of Faraday," vol. ii. p. 178.
‡ Tyndall, "Heat as a Mode of Motion."

* See "Monthly Microscopical Journal," for March, 1876.

nected with nutrition. A particle capable of germination or growth receives an impulse from a particle of an opposite sex, that is, of one in a different molecular condition, and development is stimulated and caused to take place so as to repeat with minor variations the parent forms. The well-known facts of inheritance show that, although the female germ and the stimulating male element—the ovule and pollen grain of a plant, for example—are very minute, they are big enough to contain, in some form, or way, forces which cause all fresh matter that is assimilated to arrange itself so as to reproduce a series of parts repeating for generations with marvellous fidelity the parental types.

The same thing is noticed with animals in which the same species or the same race is reproduced from one generation to another with remarkable accuracy, extending to minute and often unexpected detail. For information on this subject the reader must be referred to the works of Darwin and other writers. What we have now to consider is whether the germ particles and sperm particles can possibly be conceived to contain enough molecules built up in definite patterns, so that, as Darwin in his theory of Pangenesis supposes, they can supply *parents* enough to enable us to regard each portion of a complex organism, plant or animal, as composed of their lineal descendants. "If," says Darwin, "one of the simplest Protozoa be formed, as appears under the microscope, of a small mass of homogeneous gelatinous matter, a minute atom thrown off from any part, and nourished under favorable circumstances, would naturally reproduce the whole; but if the upper and lower surfaces were to differ in texture from the central portion, then all three parts would have to throw off atoms, or gemmules, which, when aggregated by mutual affinity, would form either buds or the sexual elements. Precisely the same view may be extended to one of the higher animals, although in this case many thousands of gemmules must be thrown off from the various parts of the body." *

To compose a plant under this theory, the seed must contain gemmules which attract suitable matter to form root-fibres; other gemmules that in like way cause cells to grow and aggregate to make a fibrous stem, others to supply the sap, others to cause the growth and development of the leaves, flowers, and finally to supply the ovule and the pollen with a complete set of gemmules to carry on the process from one generation to another; and as certain peculiarities of distant ancestors sometimes suddenly appear in their descendants, the ancestral gemmules must be sufficient in number to last for many generations, or they must act as parent cells and produce other cells.

Mr. Sorby applied himself to this problem, and sought to find what quantity of molecules existed in the quantities of matter that acts as germs and sperms. Supposing each gemmule contained a million molecules of the albuminous compound that is the physical basis of life, Mr. Sorby finds that "one thousand such gemmules massed together would form a sphere just distinctly visible with our highest and best magnifying powers." "If," he adds, "the gemmules were of much greater or much less magnitude, it appears to me very probable that Darwin's theory would break down from two opposite causes, or would need very considerable modification, because, if much greater, their number would be too few to transmit sufficiently varied characters, and if much less, they would scarcely contain enough of the ultimate atoms of matter to have a sufficiently varied individual character to transmit, since, of the assumed million ultimate molecules, only eighteen thousand would be of a true protoplasmic nature, the rest being water in molecular combination." Taking the $\frac{1}{5000}$ of an inch as the mean diameter of a single mammalian spermatozoon, Mr. Sorby calculates it might contain 2½ millions of such gemmules, and "if one of them were lost, destroyed, or fully developed at the rate of one in each second, this number would be exhausted in about one month; but since a number of spermatozoa appears to be necessary to produce perfect fertilization, it is quite easy to understand that the number of gemmules introduced into the ovum may be so great that the influence of the male parent may be very marked, even after having been, as regards particular characters, apparently dormant for many years."

Again, taking the germinal vesicle of the mammalian ovum as $\frac{1}{170}$ of an inch in diameter, "it might contain 500 millions of gemmules," and "if these were lost or fully developed at the rate of one in each second, this number would not be exhausted until after a period of seventeen years." If the whole ovum, about $\frac{1}{78}$ in diameter, were all gemmules, the number would be sufficient to last, at this rate of one per second, for 5,600 years! This is, however, not probable; but Mr. Sorby's remarks have completely removed all doubts as to its physical possibility from the Darwinian theory, and they prompt us to a wonderful conception of the powers residing in minute quantities of matter.

MENTAL PHENOMENA.

The student of nature stands surrounded on all sides by infinities. He can imagine no bounds to space or time; see no traces of a beginning, discover no symptoms of an end. There is an eternal flow and motion throughout the universe, a ceaseless change from power in the potential to power in the active form, and back again from the active to the potential—nothing added, nothing stationary, and nothing lost. Such is the aspect of the physical world; but what of the world of thought and will? Here we pause before a door of difficulty, and have no key to open. Let Du Bois-Reymond point it out:—

"Suppose we had arrived at an astronomical knowledge of the human brain, or even of an analogous organ in an inferior creature whose intellectual activity was limited to the sensations of well-being and discomfort. So far as regards the material phenomena of the brain our comprehension would be perfect, and our intellectual need to seek for causes would be satisfied in the same degree as it would be in regard to contraction and secretion, if we possessed astronomical knowledge of a muscle and a gland. The involuntary acts which emanate from nervous centres, without being necessarily connected with sensations, such as reflex and associated movements, respiration, tonicity, and lastly, the nutrition of the brain and spinal marrow, would be entirely known to us. It would be the same with the material changes that always coincide with intellectual phenomena, and which probably are conditions indispensable to them. And surely it would be a great triumph of science if we could affirm that such intellectual phenomenon was accompanied with certain movements of atoms in certain ganglionic cells and certain nerve tubes. What could be more interesting than to direct our intellectual vision inwards, and see the cerebral mechanism in motion corresponding with an operation of arithmetic, as we can watch that of a calculating machine; or to perceive what rhythmical movement of the atoms of carbon, hydrogen, nitrogen, oxygen, phosphorus, &c., corresponds with the pleasure we feel from musical harmony; what eddying currents of the like atoms attend the acme of delight, and what molecular tempests accompany the horrible suffering that ensues from irritation of the trigeminal nerve . . . ; but as regards the mental phenomena themselves, it is easy to see that, after acquiring an astronomical knowledge of the brain, they would remain just as incomprehensible as they are now. In spite of such knowledge, we should be arrested by those phenomena as things that are incommensurable. The most intimate knowledge of the brain to which we can aspire would only reveal to us matter in movement; but no arrangement, and no movement of material particles, can form a bridge to conduct us into the domain of intelligence. Motion can produce nothing but motion, or enter into the condition of potential energy. Potential energy in its turn can produce nothing besides motion, the maintenance of an equilibrium, the exertion of pressure on traction. The total quantity of energy remains always the same. In the material world nothing can go beyond this law, and nothing can do less than it requires. The mechanical effect is precisely equal to the mechanical cause that exhausts itself in producing it. Thus the intellectual phenomena which flow from the brain beside of, but in addition to, the material changes that occur in it are, to our intelligence, wanting in a sufficient reason. These phenomena remain outside the physical law of causality, and that is sufficient to render them incomprehensible." *—*Popular Science Review.*

* "Animals and Plants under Domestication," vol. ii. chap. xxvii.

ON THE NATURE OF THERMO-ELECTRICITY.

THE nature of the electricity which arises when two different metals are connected in a circuit, and the places of contact of the heterogeneous metals have different temperatures, has been the subject of a good deal of speculation. In a recent number of *Poggendorff's Annalen*, M. Kohlrausch advances an hypothesis in regard to it, the salient features of which we shall here endeavor to present.

"It is usual," he observes, "to place the cause of thermo-electricity in an electro-motive force at the places of contact of the different conductors, but difficulties are met with whenever it is sought to pass to definite conceptions here. The voltaic contact forces (which in the ordinary voltaic pile are accepted as the cause of the galvanic current) have evidently helped towards this hypothesis, and the next step consisted in explaining thermo-electricity as a modification of voltaic forces through temperature. But we soon perceive that in that case the ideas hitherto held as to these forces must be given up, or if this be not done, that we must again keep separate two kinds of contact forces.

"In this state of things, the remark is perhaps not superfluous, that for a theory of thermo-electricity, we do not at all require the immediate action of contact surfaces, and that we may reach a perfect agreement with known facts, if we suppose the electro-motive force to be in the interior of the separate conductors. The places of contact have then only a secondary influence. This conception we shall here develop.

"In every thermopile, when in action, there is, with the difference of temperature, necessarily a streaming over of heat from the warmer to the colder junction; because every conductor of electricity also conducts heat. Hitherto the difference of temperature of the junctions has been regarded as the cause of the electro-motive force; but with equal right we may make the attempt to lay, as basis, the other inseparable condition. We accordingly suppose, that *with a heat current* of determinate amount depending on the nature of the conductor, *an electric current is connected*, provided that other electro-motive forces are first excluded."

This idea is, indeed, not entirely new. Some years ago M. L. Hermann arranged experiments that were based upon it, and were meant to confirm it, but without success. M. Kohlrausch has now taken it up, and subjected it to a purely theoretical discussion.

Starting with the supposition that when a certain quantity of heat passes through a surface element in the interior of a conductor, a certain quantity of electricity is carried away with it, from the latter being proportional to it and dependent on the nature of the substance, M. Kohlrausch develops the formula for the electro-motive force of two metals, which have different thermo-electric constants, and different falls of temperature, and this formula shows (what experiment confirms) that the electro-motive force only depends on the temperature of the junctions, and is proportional to the difference of temperature.

M. Kohlrausch demonstrates that in a homogeneous uncrystalline conductor of varying temperature, a continuous electric current can not arise, because there is soon an accumulation of free electricity, which compensates the electro-motive force of the heat current. On the other hand, electricity has been observed in crystalline bodies, *e.g.*, in tourmaline, during the motion of heat in their interior.

Every theory of thermo-electricity, however, must explain not only the electro-motive forces, but also the so-called Peltier phenomenon—that is, the development of heat at the soldered junction of two metals when an electric current is sent through them. "The necessary supplementing of the above hypothesis for this end," says M. Kohlrausch, "is almost offered by itself, for we have only to add the supposition that *by an electric current heat is moved.* This supposition comes to agree with the known quantitative facts regarding the Peltier heat, when the reciprocity of joint conduction of electricity and heat is extended also to the amount of this." M. Kohlrausch shows that this propagation of heat in a conductor can not, on account of the equality of the thermo-electric constants, produce any action. At a junction, on the other hand, where these constants are different, there will be manifested, according to the direction of the current, heat production or absorption.

We may give this hypothesis a very simple expression if we take into consideration the proportionality, rendered highly probable by Wiedemann and Franz, between conducting power for heat and for electricity. That is, the heat-giving power of unit electric current in any body is proportional to the electro-motive force of the unit heat current in the same body.

While all the known facts of thermo-electricity are deducible from this position, there are, further, two quite unimportant concequences, which are peculiar to it—namely, first, an electric difference between two points of a body of varying temperature, and second, a difference in the heat developed by an electric current in an unequally warm conductor, according to the direction of the current. . . . .

In favor of the views here given, the following may further be remarked: that the propagation of heat and electricity in a metal are nearly allied phenomena, follows from the proportional behavior of all metallic conductors, that have been experimented with, with regard to both conductions. At least we have in heat and electricity two somehow related things which fill the same space, and, however it is to be conceived, we may expect that the movement of one of them has a moving influence on the other. . . . .

Further, the remarkable fact that the most active thermo-electric bodies are very bad conductors, speaks in favor of some connection of thermo-electricity with conduction of heat and electricity, for a mere coincidence can here have no place.

Lastly, it is to be noted that that excitation of electric properties, which is denoted by the name of pyro-electricity, appears to stand near our conception of thermo-electricity. The crystals in question are found electric only during their heating or during their cooling—that is to say, when they are traversed by a heat current. It is possible that thermo and pyro electricity are merely different expressions of one and the same reciprocal action between heat and electricity.

* Du Bois-Reymond, "Revue Scientifique," Oct. 10, 1874, p. 342.

FAC-SIMILE TELEGRAPHY.

THE one thing wanted in telegraphy by which a message may be practically transmitted over a wire and appear at the distant terminus in the *exact handwriting of the sender*, has at last been accomplished by an American electrician, Mr. W. E. Sawyer. The field opened to the telegraphic world by this invention is almost without limit.

The instruments are wonderfully simple in construction and easily comprehended.

The system is capable of transmitting over a single wire from 50 to 150 words per minute, against a possible 30 to 40 by the Morse system, which is that now in common use. But by this system a person's own handwriting is transmitted by telegraph the same as though sent by mail, and, in brief, simply accomplishes letter writing by telegraph. In order to render its operation fully understood it may be described as follows:

First, the sender of a message writes it upon ordinary white paper; the written message is then laid upon a metallic plate and passed between two rollers, with the effect of transferring the copy to the plate, which may be done any time within ten hours after writing. Then the plate containing the copy is placed upon a semi-cylindrical holder which traverses a little track, and the instrument is set in motion, the whole operation up to this point having been accomplished in less time than it takes to write it; whereas, by the Morse system, quite a number of minutes elapse before the message reaches the operator. The metallic plate is a conductor of electricity, while the lines of writing are non-conductors. Over the cylindrical plate are carried metallic points upon revolving arms; whenever the point is upon the metallic surface, the electric current passes through to the wire; the instant the point touches a line of writing, the connection is broken and a dot is made upon chemically prepared paper, placed upon a similar instrument at the receiving point. The two instruments operate synchronously—*i.e.*, the moment a point is passing over the surface of one instrument, it is followed exactly by the point on the other instrument. An ingenious mechanical arrangement perfects the transmitting powers and prevents the possibility of one instrument gaining over the other. At the same time the points are moving over its surface, the plate is moved slowly horizontally, so that the entire surface is traversed. The transferred message is, of course, in reverse, but is brought straight by running the receiving instrument in an opposite direction. Each instrument is fitted to either receive or transmit, at pleasure. The rate of speed varies according to the closeness of the writing; the points traversing the entire surface of the copy, it is immaterial as to the number of words, only the space they occupy requiring a given time to be gone over. Ordinary writing will be transmitted at the rate of from 50 to 100 words per minute.

The message, as received, is ready at once for delivery, and appears in close, dark blue dotted lines, on white paper. There is no loss of time in counting the words at the sending station, as is now the case, nor delay in getting to the hand of the operator; but, in a quarter of a minute's time from its being received, it is silently speeding its way to its destination, and automatically preparing itself for delivery. The wonderful facilities of the system render it peculiarly adapted to a large and hurried business. It is the fruit of many years' close application, hence the perfection with which it makes its appearance.

The writer of a message is, of course, as usual, supplied with blanks. In the system proposed—and which is now being perfected by the company already formed to utilize this great invention—for whatever may be written upon the blank he will pay an invariable sum of money, if under 250 miles; if over, double that amount in stamps, to be furnished by the company, and used the same as postage stamps. Whatever is written upon the blank, whether five words or fifty, will be sent for the same amount. It is so much blank passing through the instruments, and no cognizance is taken of its contents.

A company called "The United States Postal Telegraph Company" has been incorporated under the laws of the State of New-York for the purpose of constructing lines and operating under the letters-patent granted to Mr. Sawyer. President, John R. Cecil, of New-York; Vice-President, A. M. Allerton, of New-York; Secretary, George R. Williamson, of New-York; Treasurer, C. A. Kittle, of New-York; General Superintendent, James G. Smith, of Hackensack, N. J.; Electrician, W. E. Sawyer, of New-York. They will start with a capital stock of $2,000,000, which is to be increased to $10,000,000, as the extension of the lines may require.—*Boston Journal of Commerce.*

ELECTRIC LIGHT.

EXPERIMENTS have lately been made in Paris on the lighting of the large halls of railway stations by means of Gramme's magneto-electric machines. From the numerical sults tabulated (*Comptes Rendus*) M. Tresca's observation is confirmed, the force necessary to produce unit of electric light or 100 Carcel burners, increases very quickly as the total quantity of light diminishes. The force necessary to cause the formation of the voltaic arc is about 10 per cent greater than when the carbon points are in contact. A little more force was necessary with carbons of 0.009 m. than with those of 0.007 m. The force varies little with the types of 50, 100, or 150 burners. Comparing the expense of electric lighting with that of gas lighting, the former is shown to be only about a fifth or a seventh of the latter. In stations lighted by only one electric lamp, the shadows that were cast were observed to be troublesome, and it is recommended that there should in most cases, be two lamps which may lessen each other's shadows. To avoid the dazzling effect, the voltaic arc is inclosed in a globe of white ground glass. The rays passing upward are returned by a reflector.

DISPOSING OF RAW MANURE.

FOR a crop of grain or grass, or any shallow-rooting plants, in clay soil, it is an excellent plan to apply coarse, raw or undecomposed manure, and after a rain or two to wash out what soluble properties it may contain, to cover lightly with the plough—or, if the material is not too coarse, using the cultivator. The object, besides enrichment, is the action of the manure, in its fermentation, upon the soil, which a clay, especially if harsh or badly run, demands. The effect is most excellent; it mellows and enriches the soil, and at the same time prepares plant food from its crude material. Especially is the plan a good one to correct land that has been hurt by wet ploughing, having become hard and lumpy.

In this way the manure will be left at the surface, where the roots are, and get covered and held by the soil, the soil previously saturated by the rains that washed out the soluble parts before the plough or cultivator had mixed soil and manure. The land is thus prepared to receive the seed and commence growing the crop at once, and with full vigor, for the stratum of prepared ground, if of a few inches in depth, needs comparatively a small amount of manure to bring it up to a high state of fertility. The small roots of the grains will luxuriate here, feeling every sunbeam, so important in early sowing and in late growth of winter grain or timothy seeding. The lightness and porosity of the soil admit the warmth readily. Especially is this a benefit to young grass or clover, to start it, whether sown with the grain or without it. You are sure of a catch, and a full one, provided your seed is covered as a guard against drouth. And the start is the main thing in seeding down land; once established, plaster or other top-dressing will continue the crop.

By thus manuring the land, with comparatively little expense, the full benefit of the manure can be realized in one or two crops. You have the use at once, and without waste, for before the nitrates have sunk away they are taken up by the plant, and there is no escape into the air. In a word, you have your manure just where you want it, and where it will be at once converted into grain.

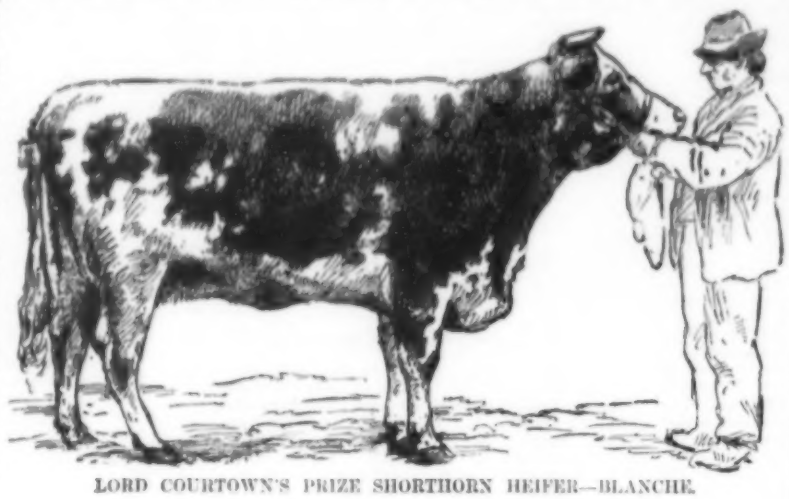
Now there is much raw manure in the spring that may be used in this way, cultivated in or ploughed shallow for the grain crop and for seeding down, especially on clay land, so as to act upon it and ameliorate it. On other soils simply harrowing in will do, and I think it is the better way, always, if possible, having it rained upon first, which will saturate the soil with its properties, and is equivalent to liquid manuring. In this way, by mixing the raw manure with the soil, the land is made the compost heap, instead of having the manure spread to the air in heaps, subject to loss from the atmosphere and the rains, requiring an extra handling, which is no small item.

The policy of keeping manure over summer is a poor one at best; there is loss of interest and loss of the properties of the manure; there is the extra handling, or, if not handled, the nuisance around the barn. It is no excuse to say it is wanted on meadows in the fall. The manure can be applied directly from the barn in the fall and winter, its benefit commencing with the first growth in the spring. It is true a start in the fall would be an advantage in the spring, but then the effect will be felt in the fall following, thus supplying fall growth, and getting at the same time the benefit of the summer's growth, instead of waste in the manure pile. Thus for grain or grass, whether fermented or not, manure can be used in the spring, or as made during fall or winter. But do not plough under deep, giving thus to the subsoil what the top wants, and leaving the top raw and unfit for the reception of seed. I have known this to do for root crops; and corn will find the manure, though it is better for either if distributed through the soil. It is best of all, however, to treat the land as first described, by keeping the manure at or near the surface, and when it is turned down, whether sod or stubble, the improved surface (turned down) will put enriched soil below, the soil brought up to be treated to manure as before. Thus the whole depth will be in fine condition for any deep-rooting crop—corn, clover, or hops. In this way our grain and grass land are made preparatory for other and deeper-rooting crops. Land treated in this way in the spring for spring crops, may be turned down in the fall for wheat, a top dressing of manure following the ploughing, to be harrowed in and mixed with the soil, the summer manure, if say is made, to be used for the purpose. Timothy may be sown immediately after the wheat is put in, and with a certainty of success. If a crop of peas instead of barley or oats has been grown on the land, all the better, and better still if as much of the haulm as possible has been left.

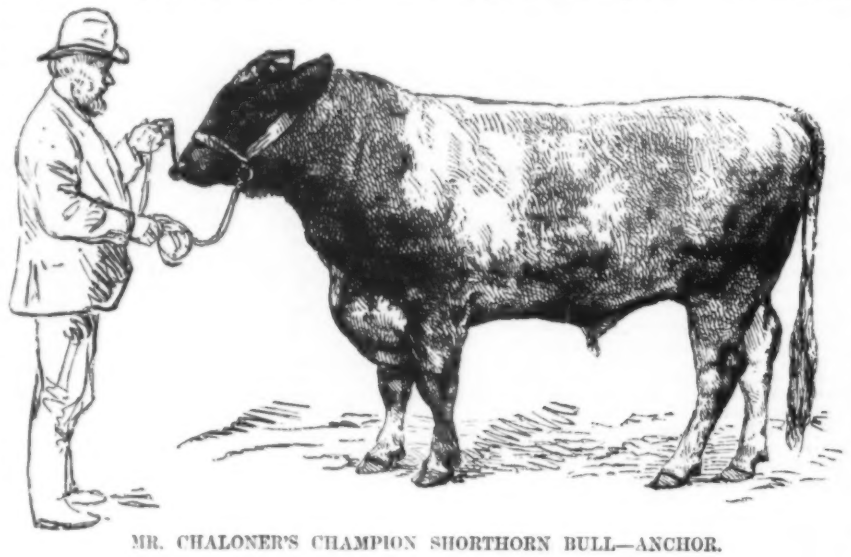
The land is thus decidedly improved, and in one season. From a rough, worn-out condition it can be brought to a good state of cultivation, not only without missing a crop, but improving greatly the crop and the crops following, and at a comparatively small expense; because the manure has been properly used, without waste, with less labor, and having its greatest effect (in its raw state) upon the land, mechanically and chemically, and our clay soils especially, when run, is preeminently the land for such treatment.—*Country Gentleman.*

ROYAL DUBLIN SPRING CATTLE SHOW.

AT the recent exhibition the entries for shorthorns were: yearling bulls, 122; two-year-old bulls, 30; older, 24. Other breeds represented were Herefords, Polled, Angus, Kerrys, Channel Island, and Ayrshires. The *Agricultural Gazette* gives the following drawings of the prize animals, and remarks that the two-year-old class was considered by the judges the best that had stood in Dublin for years. In this class Mr. Chaloner's bull Anchor took the first prize. Anchor is a bull of Booth's Medora tribe, and got by King James (28,771), a superb animal in almost too high condition to be of service; the quality of his touch was simply perfect, and though of good size he was quite level under and over; not only was he first in his class of two-year-olds, but Cup bull for the year. The budding charms of the yearling heifers were most agreeable. They were a strong class, 21 in number, much better brought out than has been the case for some years past. Out of the 21, 10 were first-class, 10 good, and only one weed.



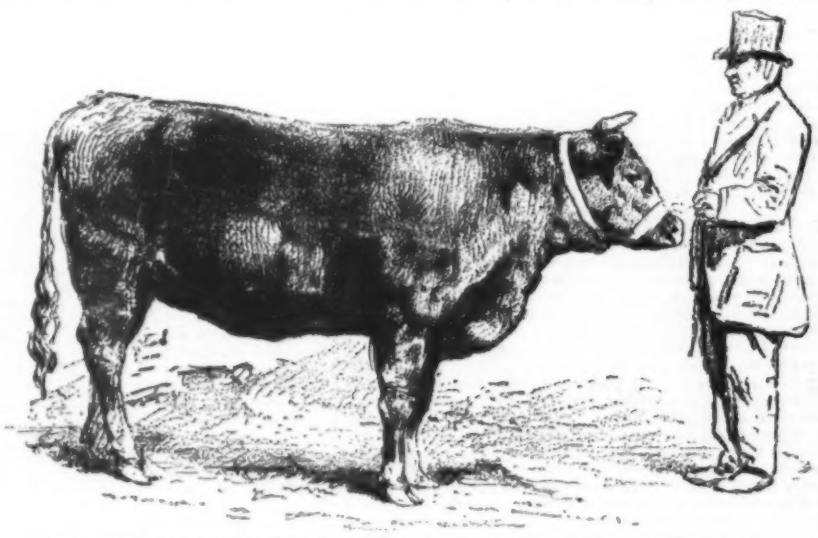
LORD COURTOWN'S PRIZE SHORTHORN HEIFER—BLANCHE.



MR. CHALONER'S CHAMPION SHORTHORN BULL—ANCHOR.

Mr. Gumbleton took first prize with Roseleaf, a level, well-backed, well-dressed, and most ladylike article (see cut). Like her half-brother, Lord Shannon, first prize, yearling bull class, without being a wonder, it would take some time to pick many holes in her soft, red velvet coat. Roseleaf is of the late Mr. Torr's Heath Rose tribe, sire Valorous (27,701), who is also the sire of Lord Shannon.

In the class for heifers in-calf or giving milk (Shorthorns) there were but two entries. Lord Courtown got first prize for his red and white cow, Blanche, shown in our engraving.



MR. GUMBLETON'S PRIZE SHORTHORN YEARLING HEIFER—ROSELEAF.

A LARGE POULTRY-YARD.

THE following account of the largest poultry-yard in this State is given in the *Plaindealer's Journal:* It is at Greene, Chenango County, N.Y., and is kept by Mr. A. B. Robeson. He has 6000 ducks, 4000 turkeys, and 1200 hens. They consume daily 60 bushels of corn, two barrels of meal, two barrels of potatoes, and a quantity of charcoal. The meal, potatoes, and charcoal are boiled together and form a pudding, which is fed warm. He has commenced to kill them off, and employs 15 hands to pick, two to kill, and one to carry away and pack on racks until frozen, then they are ready to pack for shipping. He also employs two men to cook the feed and feed them. He has 12 buildings for his fowls, from 100 to 200 feet long, 14 feet wide, and 7 feet under the eaves, with a door in each end of them. Mr. Robeson bought most of his ducks in the West, and had them shipped in crates—three dozen in a crate. He also has an egg house, 35 by 50 feet, and four stories high. The outside is 18 inches thick, and built of cut stone, laid in mortar, boarded up on the inside and filled in between the outside and inside wall with sawdust, it taking 3000 bushels. Mr. Robeson claims that he can keep eggs any length of time in this building. He also keeps the poultry that he is now dressing until next May or June, which he sells for 18 to 25 cents per lb., and it can not be told from fresh-dressed poultry. He gets 10 cents per lb. for turkey's feathers, 12 for hen's, and 65 for duck's. He says there is money in poultry, and he thinks he can make out of his 6000 ducks enough to pay for his egg house, which cost $7000. He intends to keep a great many more next season, and has agents out all over the country buying up poultry and eggs.

THE OPOSSUM.

By HOWARD MILLER.

ON the table before me, in a bottle, are some strange-looking specimens that ninety-nine persons out of a hundred would pronounce very young field-mice. There are eleven specimens in all, and they could all be packed away in a receptacle the size of a walnut.

There are but two opinions as to their identity; mice first, and then if the guesser is bold he will say young rats, only to take it back, adding that they are hardly large enough. The truth is that they are the young of the opossum, one of the strangest animals we have. The bulk of fifty such infants would not equal in size one newly born kitten or rabbit, yet the mothers are nearly equal in size.

When the young opossums are born they are about as large as a small cherry, and resemble for all the world a young terrier pup. They are as innocent of any covering but a pinkish white skin as the palm of an infant's hand.

The pouch in the mother's belly contains the teats, and on them stick the young ones—like wax, would be the orthodox comparison, but really harder and closer than a pup to an old boot. Care must be taken when they are loosened, or the head will divorce itself from the body and remain hanging to the maternal fount so closely do they adhere.

How they get to the teats is not known to me, and I doubt very much if there are many who have ever witnessed the *modus operandi* of the transfer. Being a nocturnal animal, and having passed into a proverb for shamming, I doubt very much if any one ever saw just how these poor little fellows, with their bull-pup heads and pin-tails, get hold of the teats to hold on so bravely. It is probably the case that the mother places them there. When once fastened they have to do considerable tumbling before being able to shift for themselves.

Where the mother is travelling about or lying down, her family must look out for themselves, and they are squarely on their feet only when she is lying on her back, from which I infer that they do not get many diversions of the kind. The only leading business of the first of their lives is to get a good hold and then to hang on.

When they are large enough to let loose they are then on their own hook which is, in their case, the tail. I have noticed an old one hanging by her fore-feet from a limb on a summer's night, with a double handful of well-grown opossums, with their tails twined around hers, while she was swaying to and fro, evidently giving the children a swing.

The opossum is omnivorous, and though having a decided preference for birds and their eggs, will take kindly to constructing a home inside a dead horse. In confinement it will eat anything, and would sooner be in the dark than not. Being a good digger, an expert climber, and skilful at playing 'possum when overtaken by an enemy, the question might arise as to why we are not overrun with them when they are so prolific?

The answer is [illegible] of them, [illegible] commoner than cats, but being of no value as an article of commerce, nocturnal, and not often eaten, we do not see much of them.

It has often seemed strange to me that Darwin has said so little concerning our only *marsupial*, when there is so much of scientific and general interest attached to the subject.—*Rod and Gun.*